Mosquito-borne Disease Response Plan

Washington State

Washington State Department of Health's guidance for statewide response to threats of disease, such as West Nile virus.

November 2002 Edition

The *Mosquito-borne Disease Response Plan, November 2002 Edition* includes guidance based in part on information from other state and federal agencies tailored specifically for use in Washington State. This document will be updated periodically as new information becomes available on mosquito-borne surveillance, response, and prevention. Funding for this project was through a grant from the Centers for Disease Control and Prevention.

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The response plan is available in electronic format on the Internet at: www.doh.wa.gov/ehp/ts/zoo/wnv/wnv.html

Washington State
Mosquito-borne Disease Response Plan

November 2002

Mary Selecky, Secretary

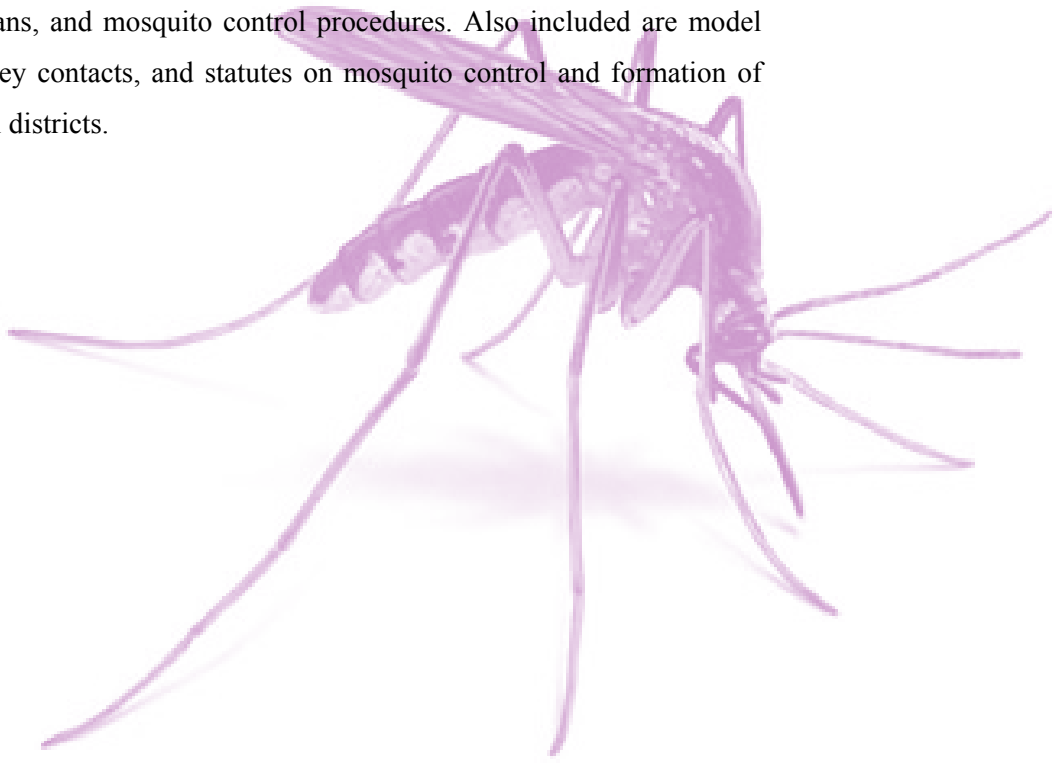
Contents

Contents

Objective

This surveillance and response plan establishes guidance for state and local agencies in preparing for and responding to the presence of mosquito-borne viruses – arboviruses, and the illnesses they cause. Detection of arboviruses, such as western equine encephalitis virus, St. Louis encephalitis virus or West Nile virus in mosquitoes or animal populations requires prompt action to reduce the risk of human infection. A finding of encephalitis cases in humans or horses requires additional control activities. The plan sets forth recommended surveillance and response procedures and describes state and local roles in responding to arboviruses.

The appendix includes detailed information on basic mosquito biology and habitat, surveillance techniques, guidelines for specimen collection from horses and humans, and mosquito control procedures. Also included are model press releases, key contacts, and statutes on mosquito control and formation of mosquito control districts.



Background

In 1998 as part of an overall program review and work plan development, the Washington State Department of Health (DOH), Zoonotic Disease Program identified a need to enhance mosquito surveillance and related activities. The importance of this project was elevated with the unprecedented outbreak of West Nile virus encephalitis in the New York metropolitan area during the summer of 1999 and expansion of the affected area in 2000. DOH and its partners initiated activities intended to improve mosquito-borne disease surveillance in the late summer of 2000. Discussions were also held on the need for developing a response plan for arboviral encephalitis.

In eastern Washington, several deaths occurred during the 1940s due to outbreaks of western equine and St. Louis encephalitis.

Washington State has a history of western equine encephalitis and St. Louis encephalitis dating back to the 1930s. The last reported case occurred in the early 1980s. Most of the cases occurred in eastern Washington in the 1940s when several outbreaks resulted in numerous illnesses and several deaths. These incidents were the driving force for creation of many of the currently operating mosquito control districts in Washington. Fifteen mosquito control districts now operate in 13 counties. Ten of the districts are in eastern Washington. Districts play a major role in identifying mosquito breeding locations, conducting larval and adult control activities and educating the public on bite prevention and habitat reduction. A list of contacts for mosquito control districts is provided in Appendix G: Key Contacts - Mosquito Control Districts.

Mosquito control districts play a vital role in the surveillance and control of mosquitoes and mosquito-borne disease, as well in the education of the community. However, many populated areas in western Washington lack the support that mosquito control districts offer.

Since the outbreaks of the 1930s and 1940s, surveillance for mosquito-borne encephalitis has been sporadic. Although the outbreaks generally heightened awareness and reporting of encephalitis for a time, routine surveillance was not established. The last comprehensive survey of mosquito species statewide was conducted in the 1960s. DOH, under a grant from the Centers for Disease Control and Prevention (CDC), began working to establish routine mosquito-borne disease surveillance with local health jurisdictions, mosquito control districts, and other partners in 2000. The grant provided an

opportunity to develop enhanced encephalitis case surveillance systems for humans and horses in cooperation with physicians, veterinarians, and local health jurisdictions. A dead bird surveillance network was also established for collection and testing of susceptible birds, primarily corvids for West Nile virus, and mosquito surveillance activities were initiated.

In 2000, CDC awards grant to Washington State for surveillance activities to detect West Nile virus.

Surveillance

Mosquito Surveillance

Identification of mosquito species and their geographic distribution is an important part of surveillance.

Mosquito surveillance is an essential component of a comprehensive mosquito-borne disease prevention and control program. The objective of mosquito surveillance is to determine species composition, geographic distribution and abundance of potential vectors of mosquito-borne pathogens within each county by collecting and identifying larval and adult mosquitoes. Up-to-date information on mosquito species and their location is essential to developing effective prevention and control programs. Samples of adult female mosquitoes can also be analyzed for the presence of arboviruses, which will help determine the primary vector species in an area.

Components of an effective program include: identifying and mapping breeding sites using ground-based and aerial surveillance methods; identifying and mapping the location of potential vector species within each county through the collection of adult or larval mosquitoes; and testing of potential vector species for arboviruses, when laboratory capacity permits.

Mosquito surveillance should start in April or early May depending on weather and continue through September and as late as October, weather permitting. Collections should be made in a variety of habitats throughout the season. Information on basic mosquito biology and common habitats in Washington are included in Appendix A: Basic Mosquito Information. Procedures on larval and adult surveillance are discussed in Appendix B: Mosquito Surveillance. DOH and its partners are available to provide training on these topics.

Bird and Mammal Surveillance

Birds and mammals can be important sentinels for mosquito-borne viruses and may provide early warning to allow for control actions to prevent human cases and reduce impacts on livestock, pets, and wildlife. Avian morbidity/mortality surveillance appears to be the most sensitive early detection

system for West Nile virus and should be a component of every arbovirus surveillance program. The surveillance system should include two components: 1) a reporting system for sightings of dead or ill birds to track increases possibly due to West Nile virus; and 2) submission of selected individual birds for testing.

Birds can be useful as indicators of mosquito-borne viruses.

The effectiveness of dead or ill bird reporting will be enhanced by collaboration with groups and individuals most likely to find dead or ill birds, such as agencies whose employees spend considerable time out of doors (parks, fish and wildlife, public utilities, etc.) and members of birding and outdoor recreational organizations.

Avian surveillance should be initiated when local adult mosquito activity begins in the spring. A database should be established to record and analyze dead bird sightings with the following suggested data; caller identification, date observed, location, species, and condition. This information should be reviewed periodically to detect increases in avian mortality. Birds chosen for testing should have died within the last 48 hours and be in good condition with no decomposition or severe trauma. Birds from areas showing a general increase in observed bird deaths are of particular value. In addition, corvids (crows, ravens, jays, and magpies) should be emphasized for testing as they are very susceptible to West Nile virus. Detailed bird submission protocols and forms are contained in Appendix C: Bird and Mammal Surveillance. Collection and shipping materials are available from DOH, Zoonotic Disease Program.

Live sentinel animals can also be used for arbovirus surveillance. Several species of birds, both wild and domestic, have been used for surveillance programs. Sentinel chickens have proven to be an important tool associated with both western equine encephalitis and St. Louis encephalitis. Their usefulness for detecting West Nile virus has not yet been fully evaluated although they have been used successfully in some east coast states. Chickens are easy to handle and have been used in Washington for western equine encephalitis, St. Louis encephalitis and West Nile virus surveillance. Caged chickens are placed in areas

of known mosquito activity and blood samples from the birds are periodically tested for antibodies to the arboviruses of concern. Positive results indicate they have been bitten by an infected mosquito. This information can help in determining appropriate response activities when used as part of a comprehensive surveillance program. Mosquito control districts or other agencies and organizations. with a field capability and laboratory support can effectively operate sentinel chicken flock programs. DOH and mosquito control districts can provide information on establishing a sentinel flock program.

Owned animals, horses, and poultry, can also provided information about arboviruses in a community. Surveillance by testing ill domestic animals is likely to be the least sensitive and specific because most animals that become ill with clinical signs of encephalitis are likely to have an illness other than a mosquito-borne disease. However, testing of symptomatic horses for western equine encephalitis and West Nile virus is appropriate. Horses have been found to be particularly susceptible to West Nile virus. Veterinarians should report equine encephalitis cases of unknown origin for testing to the Washington State Department of Agriculture at (360) 902-1878. Information on specimen submission is included in Appendix C: Bird and Mammal Surveillance. Also, poultry testing after sentinel flocks show positive antibody response can help identify geographical spread of western equine encephalitis, St. Louis encephalitis, and West Nile virus. Only persons trained in obtaining blood samples form domestic poultry should be involved in such efforts. Information on prevention and control of West Nile virus infection in equine and other livestock or poultry is in Appendix C: Bird and Mammal Surveillance.

Horses are very susceptible for certain mosquito-borne viruses.

Human Surveillance

Human case surveillance is another important component of on overall mosquito-borne disease surveillance program. This includes the need to ensure rapid and complete laboratory diagnosis of all suspect cases. Human surveillance data

should be evaluated together with mosquito, bird, and horse surveillance information to determine the level of prevention and control efforts needed to prevent outbreaks of mosquito-borne disease.

To ensure detection of human outbreaks, enhanced passive surveillance for cases of encephalitis of unknown etiology should be implemented during the mosquito season (May through September). This is passive surveillance enhanced by general alerts to key health care personnel, such as primary care providers, infectious disease physicians, neurologists, hospital infection control personnel, and diagnostic laboratories. A high index of suspicion for arboviral encephalitis should be encouraged. Appropriate clinical specimens should be submitted from suspect human cases. Appendix C: Bird and Mammal Surveillance contains information on specimen submission.

Human case surveillance should be expanded when indicator species are positive.

Active human surveillance should be initiated when other surveillance indicates the presence of arboviruses in mosquitoes, birds, or animals. This should include identifying physicians in appropriate specialties (e.g., infectious disease, neurology, and intensive care medicine) and hospital infection control personnel and contacting them on a regular basis to inquire about patients with potential arboviral infections. Physicians should be encouraged to submit clinical specimens from suspect cases.

The national case definition for arboviral encephalitis should be used to classify cases as confirmed or probable once laboratory results are available.

Rapid sharing of surveillance results with agencies and the public is essential for development of appropriate disease control measures. This may be accomplished by using established networks of health care providers, Internet sites, telephone hotlines, and press releases. However, protection of confidentiality is important for bird and mammal testing as well as for human surveillance information. Identifying information should be protected including the animal owner's name and street address, veterinarian's name and address, name and address of individual or institution submitting a specimen, and in some cases, species of bird or mammal. Summary level information should be provided to the public by local health jurisdictions.

Confidentiality is important when dealing with surveillance information.

Control

Mosquito Control

Prevention and control of arboviral diseases is accomplished most effectively through a comprehensive integrated mosquito management approach. Such a program is effective at mosquito control and minimizes public exposure to substances used for control. Programs are not intended to entirely eliminate mosquitoes but rather reduce their numbers and therefore reduce the risk of disease transmission.

Mosquito control professionals use several methods to reduce mosquito populations. These include reducing the habitat for mosquito development, control of mosquito larvae, and control of adult mosquito populations, as well as public education.

Habitat reduction can be an effective method for controlling mosquito populations.

Habitat reduction no longer involves extensive changes to the natural environment. Years ago filling or draining natural wetlands was practiced to effectively reduce mosquito-breeding areas. Today, efforts focus on modifying or eliminating breeding areas by water management practices that reduce flooding or minimize standing water in irrigated areas. Eliminating water-filled containers, such as buckets, plant saucers, cans, and tires can also help. Maintaining or draining pools, tubs, water troughs, and birdbaths, in addition to cleaning roof gutters are additional steps property owners can take. Pumps in landscape ponds and the addition of fish keep water from stagnating and provide a natural predator of mosquito larvae.

Additionally, individuals can reduce their exposure to biting mosquitoes by restricting outdoor activities when mosquitoes are active or by wearing long-sleeved shirts and long pants and using a repellant, if they choose.

When source reduction or water management is not feasible or have failed to adequately control mosquito populations, chemical or biological control may be required. Treatments may be directed at either the immature or adult stage of the mosquito life cycle.

Larviciding, the application of chemicals to kill mosquito larvae or pupae by ground or aerial treatments, is typically more effective and target-specific than

adulticiding, but less permanent than source reduction. The objective of larviciding is to control the immature stages at the breeding habitat before adult populations have had a chance to disperse and to maintain populations at levels which reduce the risk of arbovirus transmission. Larvicides can be applied from the ground or by aerial application if large or inaccessible areas must be treated. Several materials in various formulations (liquid, granular, solid) are labeled for mosquito larviciding including the organophosphate temephos, *Bacillus thuringiensis israelensis* (Bti), a bacterial larvicide, methoprene, a growth regulator and several oils both petroleum based and mineral based. Detailed information on larval control compounds is included in Appendix E, Mosquito Control. Applications of larvicides often encompass fewer acres than adulticides because treatments are made to relatively small areas where larvae are concentrated as opposed to larger regions where adults have dispersed. Larvicide formulations must be appropriate for the habitat being treated, accurately applied and based on surveillance data.

Effective use of larvicides is important in controlling the adult mosquito population.

Adulticiding, the application of chemicals to kill adult mosquitoes by ground or aerial applications, is usually the least efficient mosquito control technique. However, it is the only way to kill adult mosquitoes, and is the last line of defense in reducing mosquito populations. Adulticides are typically applied as an Ultra-Low-Volume spray where small amounts of insecticide are dispersed either by truck mounted equipment or aircraft. The insecticide must drift through the habitat in which mosquitoes are flying in order to provide optimal control benefits. Adulticides labeled for mosquito control include the organophosphates malathion and naled, some natural pyrethrins, and synthetic pyrethroids (permethrin, resmethrin and sumithrin). Insecticide selection and time of application should be based on the distribution and behavior of the target mosquito species. Additional information on adulticides for mosquito control is included in Appendix E: Mosquito Control. This appendix also includes guidance on making a determination to use adulticides for control.

Public Information

Enhanced public awareness and prevention education are two important strategies to address mosquito-borne diseases in Washington. These strategies can promote public cooperation in reducing man-made collections of standing water in which mosquitoes breed. They can also help individuals reduce their risk of being bitten by promoting bite prevention techniques. Health care providers can also be informed about the diagnosis and treatment of human arboviral encephalitis.

A public health education campaign about mosquitoes and arboviruses should accomplish the following objectives:

- Encourage personal protection techniques, such as appropriate dress, use of insect repellants, and minimizing outdoor activities between dusk and dawn.
- Improve public understanding of the sources and reservoirs of arboviral diseases such as mosquitoes, birds, and mammals.
- Increase awareness among the public and health professionals of the potential risk for infection with arboviral disease locally and when traveling to other areas.
- Encourage health care providers to promptly report cases of human encephalitis.
- Improve knowledge among health care providers of the signs and symptoms of human arboviral encephalitis.

Encouraging the reporting of dead birds in a community boosts public participation and awareness.

Public information messages serve the community about agency activities and provide suggestions about property maintenance and personal protection. Requests for public help in observation and reporting of dead birds tend to increase participation and awareness. A table for the suggested timing of messages on mosquitoes and mosquito-borne disease for the public along with example news releases are presented in Appendix

F: Release of Public Information. Messages are organized according to season. Each builds on the preceding season and reinforces earlier messages. Messages should begin in the early spring and be expanded as necessary.

Roles and Activities

Local Health Jurisdictions

Local health jurisdiction should provide personnel, either internally or contractually, necessary to conduct a routine mosquito-borne disease surveillance program. This should include personnel needed to conduct larval and adult mosquito surveillance, dead bird surveillance, human and horse case surveillance, and public information/education campaigns.

- Larval surveillance should include the location, mapping, and characterization of mosquito breeding habitats, as well as the collection and identification of mosquito species from larval habitats.

- Adult surveillance should include collection, sorting, and identification of adult mosquitoes periodically during the season, April through October.

- When laboratory capacity is available, pooling and submission of adult female mosquitoes for testing is recommended, May through September.

- All data relative to mosquito surveillance should be recorded by the local health jurisdiction.

- Dead bird surveillance should be conducted May through September with an emphasis on corvids: crows, ravens, jays, and magpies.

- Passive human case surveillance should be conducted throughout the year in cooperation with physicians. Active case surveillance should be implemented upon the finding of a human case of arboviral encephalitis.

- Public information and education campaigns should be conducted from early spring (May) through the end of mosquito season. Messages should correspond to the level of mosquito and disease activity in the county.

The local health jurisdiction should also identify organizations with mosquito control capabilities within their jurisdiction and determine if adequate capability exits, particularly in areas with known vectors or a history of mosquito-borne disease.

Washington State Department of Health

The DOH, Zoonotic Disease Program staff will assist by providing technical assistance and training on mosquito-borne disease surveillance. The department will upon request, review local surveillance and control programs, and conduct comprehensive training for local health jurisdiction surveillance personnel and others. DOH is available to provide on-site assistance to local jurisdictions in maintaining the scientific integrity of the mosquito-borne disease surveillance program. Assistance is available for:

- Identification and mapping of mosquito breeding habitat.
- Mosquito larval and adult surveillance techniques.
- Dead bird surveillance protocols.
- Preparation and shipment of specimens for identification or laboratory analysis.
- Data recording and management.

- Public information and education including news releases, brochures, website, etc.

DOH manages a statewide system for mosquito-borne disease surveillance information. Reports that summarized this information will be provided to local health jurisdictions and others on a regular basis.

Mosquito Control Districts

Mosquito control districts have been established in some counties. Most have been involved in mosquito control activities for years and can be a valuable partner to local health jurisdictions, DOH, and other agencies and organizations. Activities of these districts are regulated by the Washington State Department of Agriculture and Washington Department of Ecology.

Depending on the size and capabilities of a given district, they can help in training of local personnel and serve on local and state advisory groups. They can provide information to jurisdictions considering the expansion or formation of a mosquito control district.

The following activities of mosquito control districts can be of importance in the assessment and management of mosquito-borne disease risk in their areas:

- Collection and identification of mosquitoes and reporting of new species identified in their area to the DOH and local health officials.

- Mapping of mosquito habitat and location of vector species.

- Participating in the dead bird surveillance network.

- Providing expertise and training to public health officials on mosquito related issues including surveillance and control methodologies.

Guidelines for a Phased Response

The principal goal of a phased response plan is to minimize the health impacts of mosquito-borne arboviruses in humans, as well as in domestic and zoo animals. We have a limited understanding of the ecology and epidemiology of some arboviruses such as West Nile virus in the United States. The occurrence of arboviral encephalitis is sporadic, and the prevention methods have limitations. It is reasonable to assume that prevention and control measures, no matter how intensive, cannot prevent all mosquito-borne arboviral infections in humans.

Mosquito surveillance is the primary starting point for an effective response plan. Local health jurisdictions should know what vector species they have in their communities and where they are predominantly located. This information will increase the efficiency of any response to an outbreak of arboviral disease.

The recommended response levels for the prevention and control of the mosquito-borne arboviruses should augment long-standing mosquito control efforts by established mosquito control programs. These programs often have long-standing experience with the surveillance and control of vector mosquito species found in the western United States. These programs have established thresholds for control activities based on years of data and experience.

An appropriate response is based on a number of risk factors.

A phased response to the risks of arboviruses has been found to be effective in other states. Activities are driven in a community based on the time of year, mosquito populations, the presence of viruses in birds or mosquitoes, and animal or human cases.

The following table summarizes the various elements of risk and responses to consider. It provides guidelines to establish a phased response to protect a community from arbovirus infections.

Guidelines for a Phased Response

0 **Risk Category**
Probability of outbreak in humans: None

Definition: Off-season: adult vectors inactive, climate unsuitable.

Recommended Response: Secure surveillance and control resources necessary to enable emergency response. Initiate community outreach and public education programs.

1a **Risk Category**
Probability of outbreak in humans: Remote

Definition: Spring, summer, or fall; areas unlikely to have arbovirus epizootic during the year based on lack of previous or current arbovirus activity in the region.

Recommended Response: Response as in Risk Category 0, plus: Conduct entomologic survey (inventory and map mosquito populations); community outreach and public education; monitor avian mortality, human encephalitis/meningitis, and equine surveillance.

1b **Risk Category**
Probability of outbreak in humans: Remote

Definition: Spring, summer, or fall; areas anticipating arbovirus epizootic during the year based on previous or current arbovirus activity in the region; no current surveillance findings indication arbovirus epizootic activity in the area.

Recommended Response: Response as in Risk Category 1A, plus: Source reduction; use larvicides at specific sources identified by entomologic survey and targeted at likely amplifying and vector species; maintain avian mortality, vector and virus surveillance; public education emphasizing source reduction.

2 **Risk Category**
Probability of outbreak in humans: Low

Definition: Spring, summer, or fall: areas with initial, sporadic, or limited arbovirus activity in birds and/or mosquitoes.

Recommended Response: Response as in Risk Category 1B, plus: Increase larval control and source reduction and public education emphasizing personal protection measures, particularly among the elderly. Enhance human surveillance and activities to further quantify epizootic activity, such as mosquito trapping and testing. Consider focal or targeted adult mosquito control if surveillance indicates likely potential for human risk to increase.

Guidelines for a Phased Response

3 **Risk Category**
Probability of outbreak in humans: Moderate

Definition: Spring, summer, or fall; areas with initial confirmation of arbovirus in a horse and/or human, or moderate arbovirus activity in birds and/or mosquitoes.

Recommended Response: Response as in Risk Category 2, plus: Strongly consider adult mosquito control if surveillance indicates likely potential for human risk to persist or increase.

4 **Risk Category**
Probability of outbreak in humans: High

Definition: Spring, summer, or fall; quantitative measures indicating arbovirus epizootic activity at a level suggesting high risk of human infection (for example, high dead bird densities, high mosquito infection rates, multiple positive species, horse or mammal cases indicating escalating epizootic transmission, or a human case and high levels of epizootic activity) and abundant adult vectors.

Recommended Response: Response as in Risk Category 3, plus: Expand public information program to include TV, radio, and newspaper (use of repellents, personal protection, continued source reduction, risk communication about adult mosquito control); initiate or continue active surveillance for human cases; implement adult mosquito control program targeted at areas of potential human risk.

5 **Risk Category**
Probability of outbreak in humans: Outbreak in progress

Definition: Multiple confirmed cases in humans; conditions favoring continued transmission to humans (see Risk Category 3).

Recommended Response: Response as in Risk Category 4, plus: Implement or intensify emergency adult mosquito control program, enhanced risk communication about adult mosquito control, monitor efficacy of spraying on target mosquito populations. If outbreak is widespread and covers multiple jurisdictions, consider widespread aerial spraying.

Disease Indicator or Case Responses

Finding	Action to Take	Who to Contact
Bird positive for WNV (or mosquito pool, or sentinel flock)	▪ Expand dead bird surveillance. ▪ Review mosquito vector information. ▪ Initiate larval and adult control in key areas. ▪ Release bite prevention message to public. ▪ Conduct active case surveillance.	▪ DOH, Zoonotic Disease Program, mosquito control district, local physicians, local veterinarians, and media
Horse case of arboviral encephalitis	▪ Notify local veterinarians. ▪ Conduct active human case surveillance. ▪ Release prevention message to public. ▪ Initiate larval and adult control.	▪ DOH, Zoonotic Disease Program, DOH, Office of Epidemiology - Communicable Disease Program, Washington State Department of Agriculture - Animal Health Program, local physicians, local veterinarians, and media
Human case of arboviral encephalitis	▪ Release public announcement to media. ▪ Conduct active case surveillance. ▪ Initiate larval and adult control.	▪ DOH, Office of Epidemiology-Communicable Disease Program, DOH, Zoonotic Disease Program, local physicians, and media
New mosquito vector species identified	▪ Expand mosquito surveillance to determine distribution. ▪ Provide public information/education on habitat reduction and bite prevention.	▪ DOH, Zoonotic Disease Program and mosquito control district

Appendix A

Basic Mosquito Information

Basic Mosquito Biology

Mosquitoes are insects belonging to the order Diptera, the True Flies. Like all True Flies, they have two wings, but unlike other flies, their wings have scales and their mouthparts form a long piercing-sucking proboscis. Only female mosquitoes bite animals or humans for a blood meal to nourish their eggs. Males differ from females by having feathery antennae and mouthparts not suitable for piercing skin. Nectar is the principal food source for males.

There are about 3000 species of mosquitoes throughout the world, of which 170 occur in North America and 50 in Washington. Mosquitoes from six genera are found in Washington including *Aedes, Ochlerotatus, Culex, Culiseta, Anopheles*, and *Coquillettidia.*

The mosquito goes through four distinct stages in its life cycle: Egg, Larva, Pupa, and Adult. Each of these stages is easily recognized by their unique appearance.

Egg

Eggs are laid singly (*Anopheles, Coquillettidia, and Ochlerotatus*) or in rafts (*Culex and Culiseta*) on the surface of the water. *Aedes* and *Ochlerotatus* lay their eggs on damp soil that is subject to flooding. Most eggs hatch into larvae within 48 hours, although eggs laid in soil do not hatch until flooded and may remain viable for several years.

Larva

Larvae (plural) live in the water and come to the surface to breathe. They shed their skin four times, growing larger after each molting. The stages between molts are called instars. Most larvae have siphon tubes for breathing and hang from the water surface. *Anopheles* larvae lay parallel to the water surface to get oxygen through a breathing opening. Larvae of *Coquillettidia* attach to plants, such as cattails, below the water surface and get oxygen by inserting their siphon through the stalks or roots of the plant. Larvae feed on microorganisms and organic matter in the water and on the fourth molt change into pupae. The larval stage generally lasts 7-14 days depending on water temperature.

Pupa

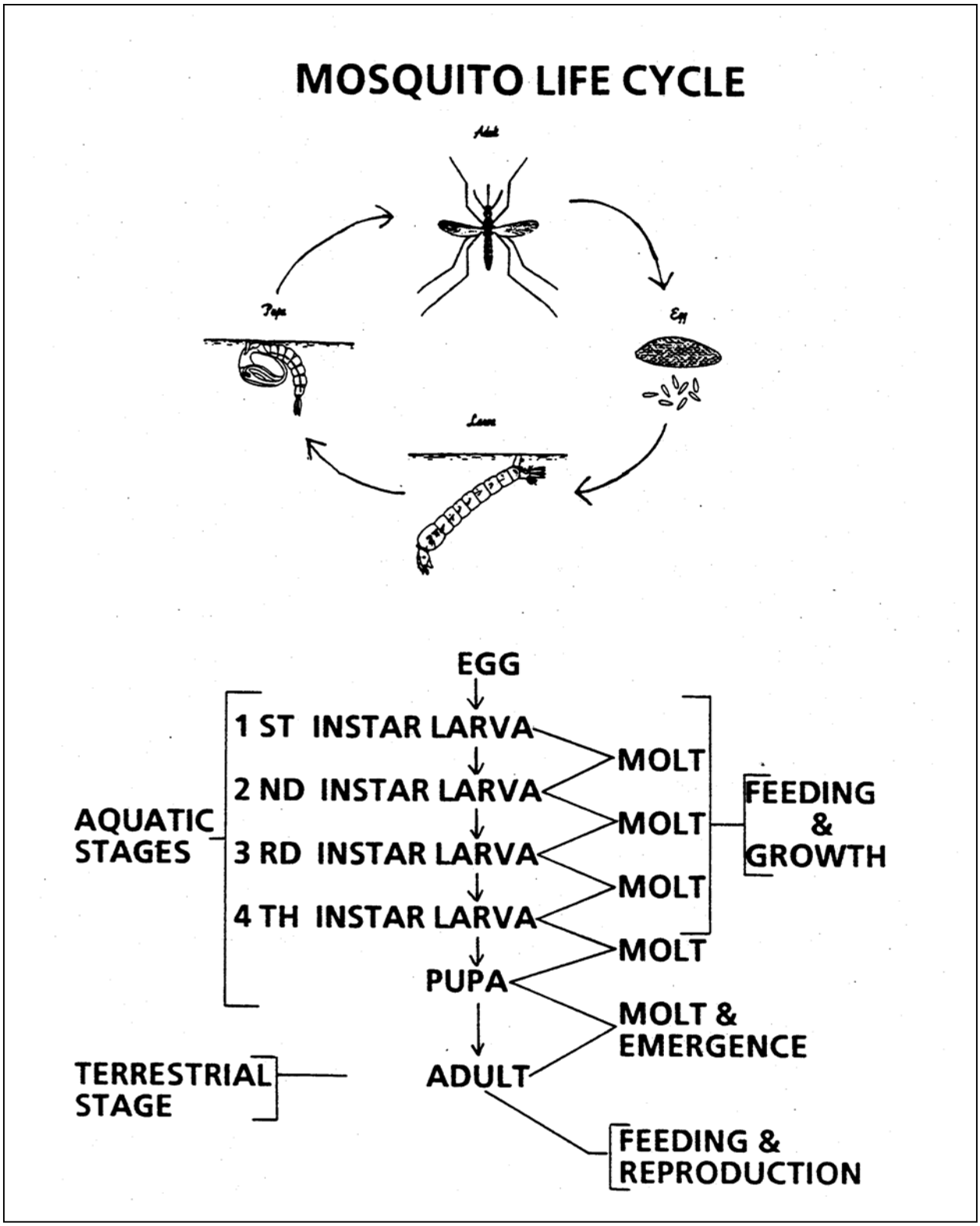
The pupal stage is a resting, non-feeding stage. When development is complete, in one to four days, the pupal case splits and the mosquito emerges as an adult.

Adult

The newly emerged adult rests on the surface of the water for a short time to allow itself to dry and body parts to harden. The wings must be dry before it can fly. The average life span of an adult mosquito is one to two months. They generally have a flight range of ½ to 2 miles but some species travel up 20 miles.

The entire life cycle from egg to adult can occur in as little as seven days or as long as a month. Mosquitoes can also over-winter in all stages except the pupal stage. Adults seek shelter in basements, culverts, or other protected areas where they hibernate and larvae can remain viable in permanent pools or containers of water. Eggs deposited in mud along rivers or in flood plains will hatch even after several years when flooded.

Mosquito Life Cycle



Principals Characters for Identifying Mosquitoes

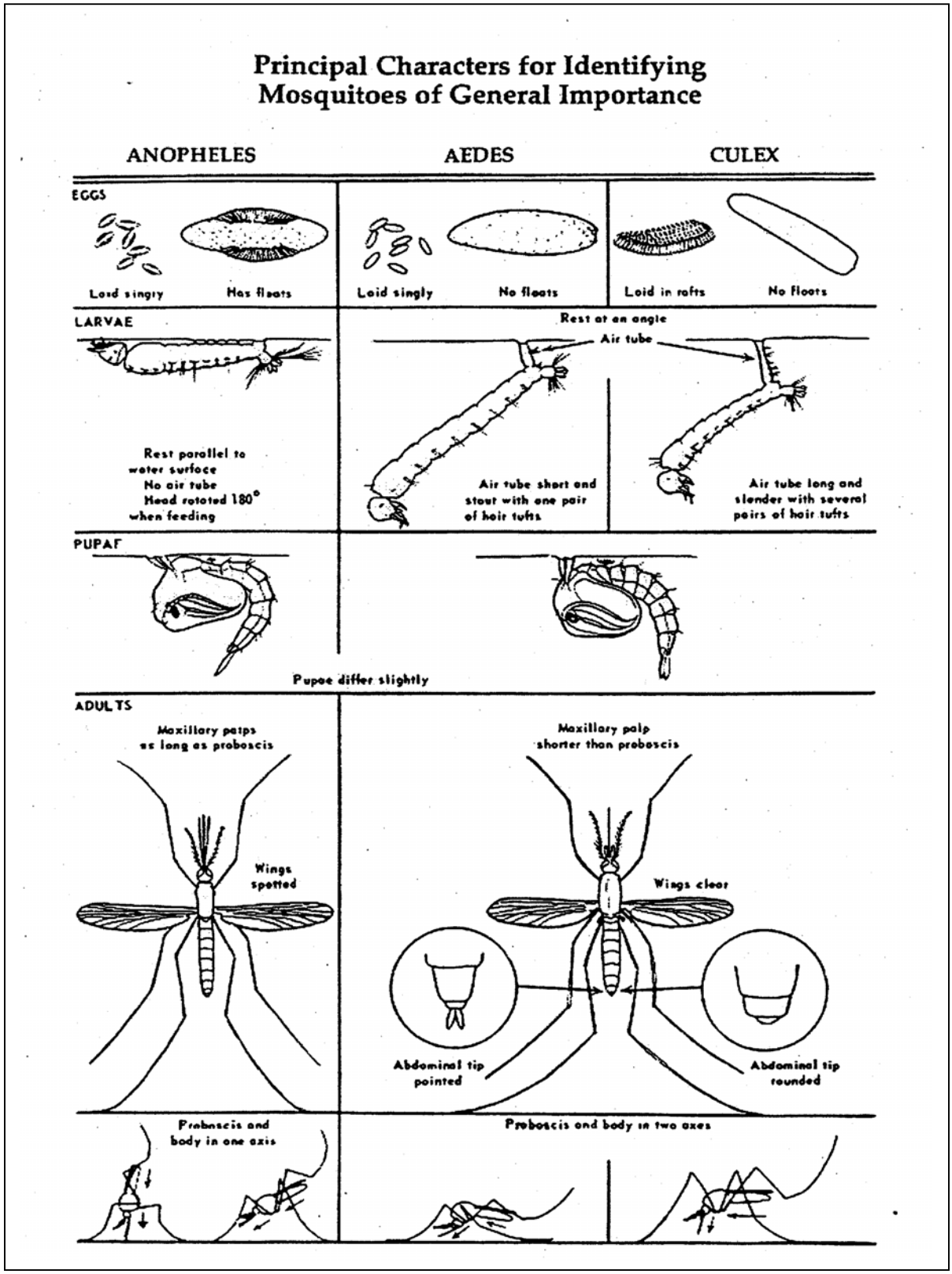


Diagram of Adult Female Mosquito

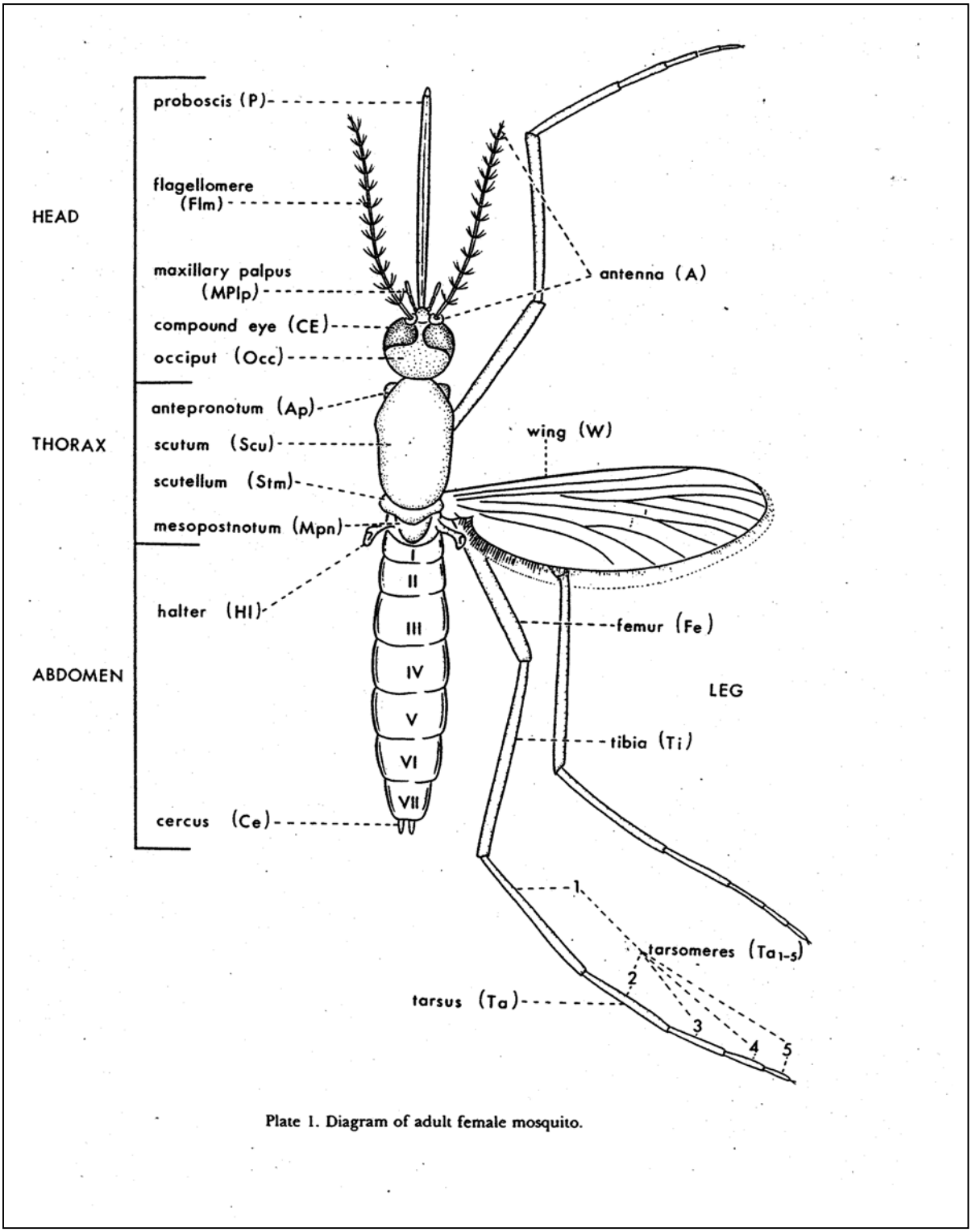


Plate 1. Diagram of adult female mosquito.

Mosquito Habitat and Control Issues in Washington

Different types of mosquito-control problems occur in the Northwest. In some areas they are caused by floodwater, in others by irrigation, and some are related to ponds and artificial containers. Mosquitoes that breed in permanent or semi-permanent pools will usually be found in most localities.

Floodwater

Aedes vexans and *Ochlerotatus sticticus*, which develop in large numbers along the borders of the Columbia and other rivers, create one of the most important mosquito problems in this region. The larvae hatch in the spring or early summer when the streams overflow areas such as willow and cottonwood swales where the eggs have been laid. The eggs of these species are dormant when temperatures remain below 45°-50° F. Partial dormancy of the eggs may continue until some time in June so that only some of the eggs are hatched by floods occurring in April or May.

In some seasons the larger rivers may rise, recede, and rise again to cover the same egg beds and produce an additional hatch. In other seasons two or three successive rises may occur, each of which is higher than the last. Females that emerge in the first hatch may lay eggs that will hatch in the second or third rises of the river. Most of the eggs are laid between the 10 and 20 foot levels, and some of the eggs that are not flooded during a series of low flood crest years remain viable for as long as 4 years.

Large *Aedes vexans* and *Ochlerotatus sticticus* breeding areas have been managed efficiently in the past by controlling water levels above Bonneville Dam. Dikes have prevented flooding in other areas. Clearing of brush has been of value in some special locations. However, control of the major section of these types of breeding areas must often be accomplished with insecticides against the larval or adult mosquitoes.

Irrigation Water

Breeding places for several mosquito species are provided by irrigation water. *Aedes dorsalis*, *A. vexans*, *Ochlerotatu melanimon,* and *Ochlerotatus nigromaculis* are among the most important species that may develop when water is applied and stands for a week or 10 days. Other species such as *Culex tarsalis*, *Culiseta inornata*, and *Anopheles freeborni* may be produced if water remains for longer periods. Tremendous numbers of mosquitoes breed in many areas where uncontrolled irrigation is practiced. Applications of insecticides to control the larvae or adults that have emerged are effective but are not substitutes for proper grading.

Elimination of standing water is effective in preventing development of mosquitoes. Application of insecticides may be necessary for breeding places that cannot be drained.

Tidal Waters

Aedes dorsalis is the only species that can breed in large numbers in both fresh and salt water in the Northwest. The larvae develop in some coastal areas where potholes are filled by the higher tides or where water levels fluctuate in permanent or semi-permanent pools. Leveling, drainage, or similar practices are effective in preventing breeding, but such areas must be properly maintained. Insecticide control of the larvae or adults may be necessary where these methods are inadequate or ineffective. *Ochlerotatus togoi* has also been found in coastal areas including San Juan, Island, Skagit, Kitsap, and Mason counties. Larvae of this species have been found in pools of pure seawater along rocky shorelines.

Snow Water

In many high mountain meadows and also at lower levels mosquitoes breed in pools caused by snow melt. Development may require several weeks at higher elevations. *Aedes communis, A. cinereus, Ochlerotatus hexodontus, O. fitchii,* and *O. increpitus,* are the most common species found in these locations. Usually there is only one generation per year, but the large numbers that may be produced are a severe annoyance to those who are working or seeking recreation in these areas.

Elimination of breeding areas by drainage or maintenance of constant water levels is practical in some situations. Insecticide applications might have to be made by hand or by plane because of inaccessibility to heavy ground equipment.

Ponds and Artificial Containers

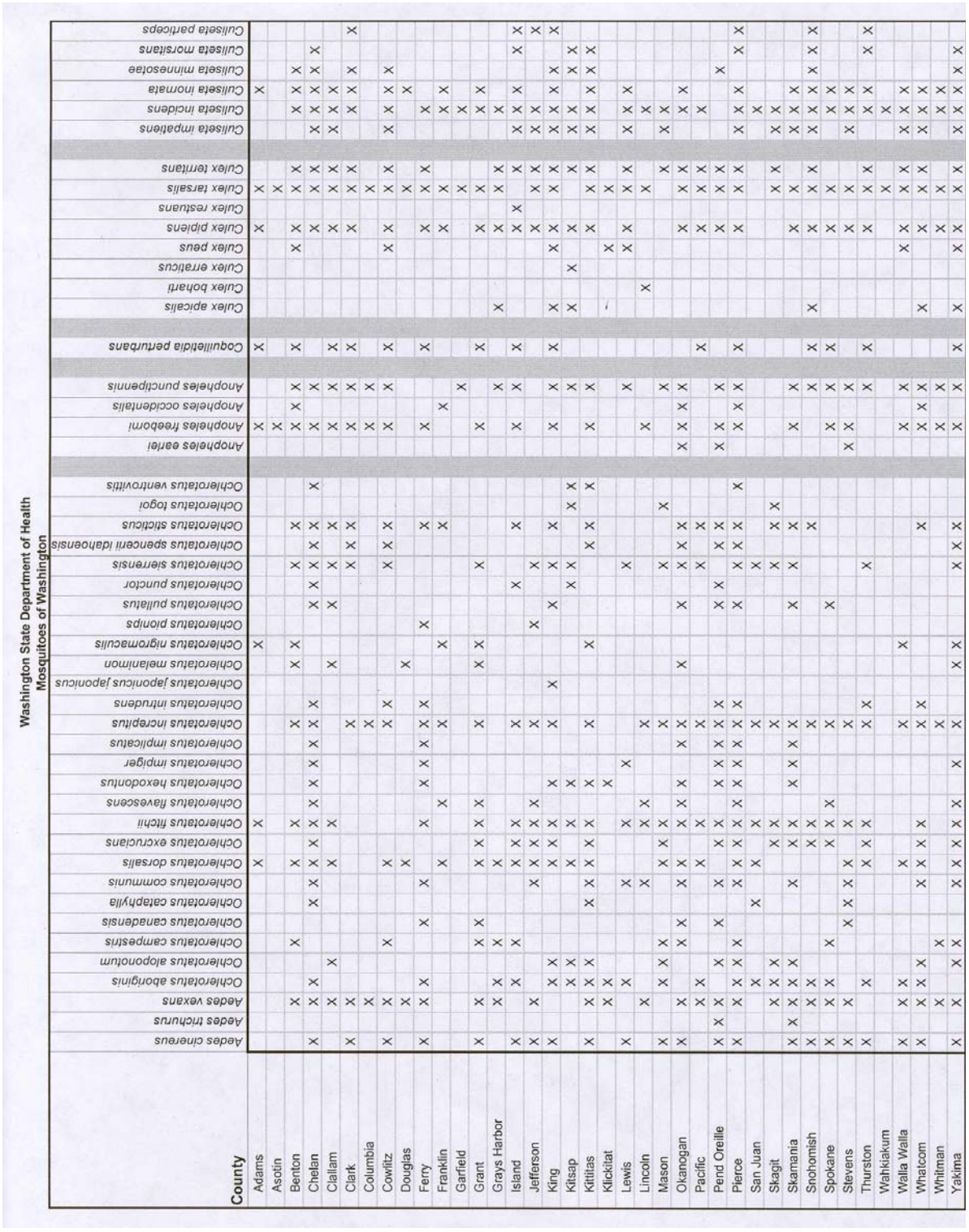
The mosquitoes that lay their eggs on the water are usually found where water is present continuously during the season or at least for several days. Such locations include natural permanent ponds, log ponds, semi-permanent ponds of various types, and artificial containers. *Culex tarsalis, C. pipiens, C. peus, Anopheles freeborni*, *A. punctipennis, Culiseta incidens*, and *C. inornata* are commonly found in such places. *C. tarsalis* and *C. pipiens* develop in large numbers in log ponds. *C. pipiens* also develops in large numbers in sewer drains, catch basins, and water left in artificial containers. *Coquillettidia perturbans* is found in permanent water in swamps and marshes that have emergent or floating vegetation.

Insecticides are often used effectively to control most of these species, except those breeding in artificial containers. Water standing in barrels, cans, old tires, and other receptacles should be emptied. Larvae of *C. perturbans* are difficult to control because they are attached to the roots of plants. Insecticide

granules are sometimes applied, but eliminating host plants may be the most useful procedure to control this species.

Mosquito Species Identified in Washington State

November 2002



Potential West Nile Virus Mosquito Vectors in Washington

The following mosquitoes, present in Washington, are species from which West Nile virus has been isolated and/or West Nile viral ribonucleic acid (RNA) detected in parts of the country where West Nile virus is present. Isolation of West Nile virus or detection of West Nile viral RNA in a mosquito species does not necessarily incriminate that species as a competent vector of the disease. It is only an indication that the species has come into contact with the West Nile transmission cycle. Vector species in Washington will only be determined after the virus is present in the state.

Culex pipiens

Commonly called the northern house mosquito, this species is widespread in Washington and readily enters homes. Although they occur in rural environments, they reach their greatest numbers in urban and suburban areas. They breed in catch basins, stormwater ponds, clean and polluted ground pools, ditches, animal waste lagoons, log ponds and other waters rich in organic matter. This species also deposits eggs in artificial containers such as tin cans, tires, birdbaths, etc. Larvae may be present from spring through fall. *Culex pipiens* readily utilizes birds as bloodmeal hosts and will feed on mammals, including humans and dogs. The wide distribution of this species, especially in highly populated areas, makes it a species of concern for West Nile virus.

Culex tarsalis

Probably the most widespread species in Washington, found in nearly all counties. The larvae develop in many types of permanent and semi-permanent waters such as log ponds, stormwater ponds, ditches and marshes in either clean or polluted water. Larvae may also be found in artificial containers such as tires, tin cans and ornamental ponds. This species prefers to feed on domestic and wild birds but will bite man, livestock and other animals. It has a flight range of several miles. Primarily an evening biter, this species is the most important vector of western equine encephalitis and St. Louis encephalitis.

Aedes vexans

One of the most common floodwater mosquitoes, this species is found in large numbers in irrigated and floodwater areas. Eggs are laid in mud and hatch when flooded in the spring or early summer. Several hatches may occur each season if water levels recede and rise, however, the eggs will remain viable for several years if flooding does not occur. This species may be present in large numbers

along the Columbia and other rivers and has a flight range over 20 miles. They are vicious biters and will feed during the day but more commonly bite at dusk.

Aedes cinereus

This mosquito can be found in a wide range of larval habitats but is most frequently found in woodland and open meadow pools ands cattail swamps. In some mountain areas it is the predominant species. It does not travel far from its larval habitat. This species will bite any time during the day, and is known as an ankle biter because it focuses on the lower extremities.

Anopheles punctipennis

The larvae of this species are usually found in pools of fresh water containing vegetation that are around for several weeks such as natural ponds or log ponds. They may also be found in grassy pools along creeks and rivers and in artificial containers and other environments associated with Culex tarsalis and Culex pipiens. They are aggressive day and dusk biters and feed on large mammals, including cows and horses, as well as humans. They do not fly far from their breeding sites.

Coquillettidia perturbans

This species breeds in marshes, ponds and lakes that have a thick growth of aquatic vegetation. Larvae attach to the stalks of vegetation and do not need to rise to the surface to breath, making control difficult. They have been found in stormwater ponds containing cattails or other aquatic vegetation. They are fierce biters, active primarily in the evening, but will bite during the day.

Ochlerotatus japonicus

A recently discovered species only documented to be in King County. Larvae are found primarily in artificial containers, depressions filled with water, tires, birdbaths, etc. This species is a daytime biter making avoidance difficult. The distribution of this species will be better understood as more surveillance is undertaken. Habitat reduction by eliminating standing water and water in containers is important in controlling the population of this species.

Ochlerotatus canadensis

Found in woodland pools filled by melting snow or rain, this species is one of the first to emerge in the spring. It can be a serious pest in shaded areas near its breeding site and the adults live for several months. It feeds on a broad range of animals including large and small mammals, birds and reptiles.

Culiseta inornata

This species breeds in woodland pools primarily but can also be found in any stagnant water including artificial containers. It can be found at elevations up to 6000 feet in very cold water. It is a serious pest of livestock due to its long breeding season and wide distribution in irrigated areas. Often found associated with *Anopheles freeborni* and *Culex tarsalis.*

Potential West Nile Virus Mosquito Vectors in Washington

November 2002

Western Washington

County	Mosquito Species								
	Aedes cinereus	*Aedes vexans*	*Anopheles punctipennis*	*Coquilletidia perturbans*	*Culex pipiens*	*Culex tarsalis*	*Culiseta inornata*	*Ochlerotatus canadensis*	*Ochlerotatus japonicus*
Clallam		✓	✓	✓	✓	✓	✓		
Clark	✓	✓	✓	✓	✓	✓	✓		
Cowlitz	✓	✓	✓	✓	✓	✓	✓		
Grays Harbor		✓	✓		✓	✓			
Island	✓		✓	✓	✓		✓		
Jefferson	✓	✓			✓	✓			
King	✓		✓	✓	✓	✓	✓		✓
Kitsap			✓		✓				
Lewis	✓		✓		✓	✓	✓		
Mason	✓		✓						
Pacific		✓		✓	✓	✓			
Pierce	✓	✓	✓	✓	✓	✓	✓		
San Juan									
Skagit		✓				✓			
Skamania	✓	✓	✓		✓	✓	✓		
Snohomish	✓	✓	✓	✓	✓	✓	✓		
Thurston	✓		✓	✓	✓	✓	✓		
Wahiakum						✓			
Whatcom	✓	✓	✓		✓	✓	✓		

Potential West Nile Virus Mosquito Vectors in Washington

November 2002

Eastern Washington

County	*Aedes cinereus*	*Aedes vexans*	*Anopheles punctipennis*	*Coquilletidia perturbans*	*Culex pipiens*	*Culex tarsalis*	*Culiseta inornata*	*Ochlerotatus canadensis*	*Ochlerotatus japonicus*
Adams				✓	✓	✓	✓		
Asotin						✓			
Benton		✓	✓	✓	✓	✓	✓		
Chelan	✓	✓	✓		✓	✓	✓		
Columbia		✓	✓			✓			
Douglas		✓				✓	✓		
Ferry	✓	✓		✓	✓	✓		✓	
Franklin					✓	✓	✓		
Garfield			✓			✓			
Grant	✓	✓		✓	✓	✓	✓	✓	
Kittitas	✓	✓	✓		✓	✓	✓		
Klickitat		✓				✓			
Lincoln		✓				✓			
Okanogan	✓	✓	✓		✓	✓	✓	✓	
Pend Oreille	✓	✓	✓		✓	✓		✓	
Spokane	✓	✓	✓	✓	✓	✓	✓		
Stevens	✓	✓	✓		✓	✓	✓	✓	
Walla Walla	✓	✓	✓		✓	✓	✓		
Whitman		✓	✓		✓	✓	✓		
Yakima	✓	✓	✓	✓	✓	✓	✓		

Appendix B

Mosquito Surveillance

Techniques and Equipment for Adult Mosquito Surveys

Centers for Disease Control and Prevention, Guidelines for Arbovirus Surveillance in the United States, 1993, Appendix II 51-54.

Adult mosquitoes are collected to obtain a variety of information: species composition, relative density, population age structure, arbovirus infection, rates etc. Adult surveys also can provide data on seasonal and spatial distribution of the vector(s). Depending on the type of information desired, different collection methods and equipment may be required. We must know which methods and equipment to use for a given purpose. A full discussion of the various traps and methods available is beyond the scope of these guidelines.

Resting Population

Adults of many mosquito species are inactive during the day, resting quietly in dark, cool, humid places. An index of the population density can be obtained by carefully counting the number of adults found in a resting station. These sampling sites are also a source of specimens for arbovirus tests. Sampling resting adults usually provides a representative sample of the population: collections include teneral unfed, post-teneral unfed, blooded, and gravid females, as well as males. Population age structure also is more representative. However, different species and different gonotrophic stages may prefer different types of resting sites. Sampling resting populations is usually time consuming, especially when looking for natural resting sites. The number of specimens collected per unit of effort may be low compared to other collection methods. Mosquito resting stations are divided into two general types, natural and artificial.

"Natural" resting sites: Natural resting sites include any location not specifically constructed to serve as shelter for mosquitoes. Examples are storm sewers and culverts, bridges, houses, porches, barns, stables, chicken houses, privies, rodent burrows, tree holes and vegetation. With experience the suitability of shelters as adult mosquito resting stations is easily evaluated. Collections must be standardized for accurate comparison of results.

"Artificial" resting sites: Artificial resting stations may be constructed when suitable natural resting stations are not available. Many different types of artificial shelters have been used, including the nail keg resting station, red boxes, red cloth shelters, and privy-type shelters. [258] These shelters should be placed in shaded, humid locations near suspected breeding places or in other known congregation sites. Most species probably enter such shelters around dawn probably in response to changes in light intensity and humidity, and ordinarily do not leave until dusk. Artificial shelter boxes, one cubic foot in size with one side open and painted red on the inside, have been used successfully for several species in the United

States. [258] In studies of *Cx. tarsalis* and other species in California, walk-in red boxes have been very effective. [243]

Equipment: A variety of aspirators are available (hand-held, sweeper – BFS, Nasci, D-Vac, etc.). In addition, specimens can be collected with a sweep net or they can be killed or immobilized by several materials (pyrethroids, chloroform, triethylamine, etc.) The de Zulueta (drop net) cage is useful for collecting specimens resting in grass or low vegetation.

Non-attractant Traps

Non-attractant traps give a more representative sample of the population than attractant traps, but only sample the airborne population. A representative sample is not always desirable. For virus studies, it is better to bias collections toward collection of physiologically old females. Representative samples are highly desirable for general ecological studies. Unfortunately, these traps tend to collect few specimens. Placement is crucial. Some species may not be collected at all because they don't pass through the area where the trap is placed.

Examples of non-attractant traps include the malaise trap, the ramp trap, truck traps, sticky traps, and suction traps.

Animal Baits, Attractants and Landing/Biting Collections

Animal-baited and CO_2 –baited traps disproportionately attract host-seeking females. This is the segment of the population of greatest interest for arbovirus surveillance. The bait species is important in trap performance. Often there is significant inter-host variability in attractiveness, which may affect trap performance. Other considerations are the duration of collection (especially human landing/biting collections), and time of day (especially important for species with a narrow host-seeking window). A final consideration is the need to decide whether to let mosquitoes feed or not (e.g., will specimens be used for blood meal identification?). Specimens can be removed from the trap periodically with a hand aspirator.

CO_2 –baited traps rely on the sublimation of dry ice (occasionally on bottled CO_2) to provide the attractant, imitating CO_2 release by the host in animal-baited traps. Another material, 1-octen-3-ol, has recently been used either alone or with CO_2 as an attractant in bait traps.

Landing/biting collections, usually using humans or horses, sample selected portions of the mosquito population, particularly in studies to incriminated specific vectors or in other research applications. [258] When using human bait, consideration must be given to the potential health risks involved. Particularly during epidemics, it is advisable to restrict these activities to naturally immune or immunized individuals.

Many animal-baited traps have been designed. [258] These generally are used for special studies rather than for routine surveillance. One important application for these traps is in determining the probable vector(s) of a particular virus to a given host)e.g., EEE or WEE in horses). [188, 302]

Drop nets and tent traps: These traps normally are left open or are suspended above the bait (human or animal). After a set period, the openings are closed or the net lowered and the trapped mosquitoes are collected. [258] Traps can be small (e.g., for a rabbit, chicken, monkey, single human) or large (e.g., screen rooms for horses and other large animals). Large, screen rooms have been effective in vector studies in Argentina and the U.S. [188, 302]

Magoon trap: This trap is similar in principle to the tent trap, but is more substantial in design, which provides some restraint for larger bait animals. [169] Mosquitoes enter the trap but cannot escape, and they can be collected periodically. Several variations have been proposed. An interesting design uses a livestock crush or squeeze chute surrounded by a screened cage with entry baffles. [151] A modification designed for humans utilizes an inner screened enclosure that prevents the trapped mosquitoes from biting the bait/collector. [226]

Entrance/exit traps: These traps have a long history of use in malaria research. [258] A variation with application to mosquito-borne encephalitis studies is the sentinel chicken shed. [231] The trap consists of a portable chicken shed and one or more removable mosquito traps. Mosquitoes attempting to enter the shed to feed are collected in the traps and can be removed the following morning.

Small animal bait traps: A bird-baited CDC light trap collected significantly more *Cs. melanura* and *Cs. morsitans*, but significantly fewer *Ae. vexans* when compared to a CO_2-baited CDC light trap. [97]

Lard can traps: An economical, portable mosquito trap, made from a 12-inch lard can, has been developed[18] and is very effective in capturing *Cx. tarsalis* and *Cx. nigripalpus*. The trap is equipped with inwardly directed screen-wire funnels on each end. It utilizes about 3 pounds of dry ice (wrapped in newspaper) placed inside the can. The lard can trap also can be baited with a live chicken or other animal. An inner, double screened enclosure can be used to prevent feeding by the trapped mosquitoes. [84]

Dry ice and hand aspirator: *Ae. albopictus* adults can be collected by having the collector stand over or near a small block of dry ice. Females that are attracted by the CO_2 can be collected with a net or hand-held aspirator as they fly around the collector's legs.

DeFolart-Morris conical trap: This is a cone trap, baited with dry ice. The attracted mosquitoes are anesthetized by the CO_2, and slide into a chamber containing dry ice where they are frozen. [77]

Duplex cone trap: Designed specifically for *Ae. albopictus*, this trap was very effective in field trails in Louisiana. [104]

Light trap with or without light: Light traps are frequently operated with dry ice as an additional attractant. For a discussion of this procedure, see "Light traps," below.

Light Traps

Many mosquito species are attracted to light, making it possible to sample adult populations between dusk and dawn. Light traps probably work by disrupting the normal behavior of flying mosquitoes. Mosquito species respond differently to these traps. Some species are not attracted to light at all, and may even be repelled (e.g., *Cx. quinquefasciatus*). Light traps only sample the flying population. The catch is influenced by many factors, including light source, wavelength and intensity. Competing light sources (including moonlight, roadside lights, and "urban glow"), fan size and speed, and presence or absence of screens also affect trap performance.

Trap placement (height, location in relation to trees and other cover, proximity to breeding sites, etc.), can have a marked effect on the species and numbers of mosquitoes collected. Some trial and error placement is frequently involved in locating good trap placement sites.

The light trap is usually suspended from a tree or post so the light is approximately 6 feet above the ground. It should be 30 feet or more from buildings, in open areas near trees and shrubs. It should not be placed near other lights, in areas subject to strong winds, or near industrial plants emitting smoke or fumes. Traps should be operated on a regular schedule from one to seven nights per week, from just before dark until after daylight.

Because differences have been noted in the reactions of different species of mosquitoes, light trap collections must be used in conjunction with other population sampling methods. Light traps are very useful in measuring densities of *Cx. tarsalis*, but less so for *Cx. p. quinquefasciatus. Culex p. pipiens* in northern areas may be collected in light traps. *Culiseta melanura* is routinely sampled with light traps in Massachusetts.

Dry ice, added as an attractant with light traps, [221] increases collections of many mosquito species including *Culex tarsalis* and *Cx. nigripalpus*. A small block of dry ice, placed in a padded shipping envelope or wrapped tightly in newspaper, is suspended a few inches above the light trap.

New Jersey light trap: The New Jersey-type light trap was developed in the early 1940's. [208] It is widely used in adult surveys because of its attraction to mosquitoes and its durability. This is a standard device used by mosquito control agencies in the United States. It can be operated manually or used with an automatic timer or photo-electric cell to start and stop the motor and light. The collection may be funneled into a killing jar. This makes the collection acceptable for relative abundance studies, but unacceptable for arbovirus studies that require live specimens. A fine-mesh collecting bag can be substituted for the killing jar when living specimens are required. Collections are gathered each morning and placed in a properly-labeled container until the mosquitoes can be sorted, identified, and counted. Live catches are processed immediately. A newly-developed antigen capture enzyme immunoassay (EIA)

test can detect SLE viral antigen even in dead specimens. [287] The New Jersey-type trap depends upon a 110-volt source of electric power, which somewhat restricts its use.

CDC light trap: The CDC miniature light trap was developed for greater portability. It can be taken to remote areas that could not otherwise be sampled by a trap dependent upon electricity. It is commonly operated with four 1 ½-volt "D" cell flashlight batteries, or one 6-volt motorcycle battery, which provide sufficient power for one night's trapping. [277] It weighs only 1 ¾ pounds and is easily disassembled for transport. The CDC trap is fitted with a large, collapsible, nylon collecting bag (or a cardboard carton) instead of a killing jar. In this way, the catch is captured and held alive until the specimens can be frozen. The trap has large metal or plastic canopy that shields the operating mechanism from rain. The collecting bag can be further protected in areas with heavy rain: 1) take a plastic bag large enough to fit over the mesh collecting bag, 2) cut a hole slightly larger than the diameter of the light trap body, 3) place the upside-down bag over the mesh collecting bag. Make sure the bottom of the mesh bag is unobstructed, so air can freely flow through the light trap. The CDC light trap does not compete well with other light sources and smaller catches may result during a full moon. When the CDC trap is used with CO_2 and no light, *Cx. tarsalis* can be collected without many of the other insects that are normally attracted by the light (W.C. Reeves and J.L. Hardy, personal communication, 1992). Several modifications of the CDC light trap are also commercially available.

Oviposition Traps

Oviposition traps sample the gravid population. This can be an advantage for many epidemiologic studies. Since the gravid population has fed at least one time, these individuals are more likely to be infected. This reduces the work involved in processing mosquito pools for virus isolation. Minimum infection rates (MIRs) will, on average, be higher than those obtained, for example, from CDC light trap catches. Traps can be separated on the basis of whether or not they retain the ovipositing females or allow them to escape.

Ovitraps: Ovitraps only sample eggs, but the number of *Culex* rafts can be used to estimate the ovipositing (and therefore recently-fed) adult female population. Several trap designs are available for various mosquito genera and species. In general, ovitraps for *Aedes* species are small (CDC ovitrap, [99] Loor & DeFoliart [164]). Traps for *Culex* usually are larger, and usually have an attractant or infusion. [245]

Reiter gravid trap: The Reiter gravid trap samples female *Culex* mosquitoes as they come to oviposit. [244, 246] It therefore is selective for females that have already taken at least one blood meal. If mosquitoes are being collected for virus isolation, there is a higher probability of collecting infected mosquitoes. [248] Gravid trap counts might also have a higher correlation with disease transmission. The

Harris County Mosquito Control District in Houston, Texas, has used these traps successfully in their SLE surveillance program.

Seven Ways to a Successful Dipping Career

Claudia O'Malley, C. 1995.
Seven ways to a successful dipping career. Wing Beats, vol. 6(4): 23-24.

Introduction

As recently as 1922, members of the New Jersey mosquito control community were debating the relative merits of "night collections" as opposed to larval collection and identification. Some of the past practices of mosquito control included treating any standing water encountered, regardless of whether or not mosquito larvae were present. Guidelines for starting a mosquito control program included the advice that directors should not spend an excessive amount of time on surveys. Even now, a few still feel that larval surveys are only necessary in the early part of the breeding season; once it is known what species are present at a site, it can be taken for granted that the species composition at that site will remain the same throughout the rest of the season. Most experts, however, feel that larval surveillance is not only an important aspect of an effective mosquito surveillance and control program, but it is an essential component.

Benefits of Larval Surveillance

Larval surveys have many important functions. They are used to determine the locations and seasons that mosquitoes use specific aquatic habitats and, when specimens are identified and counted, the information can be used to determine species composition and population densities. The information can be used to determine optimal times for application of larval control measures, including chemicals, biologicals, draining or impounding. It can also be used to help forecast the need for adult mosquito control and to help assess the effectiveness of both chemical and biological control measures.

Routine larval surveillance data can be useful in interpreting adult mosquito surveillance data. For example, if larval surveys indicate 95-100% control by larvicides and yet the number of adults does not decline, one can suspect, in the absence of reinfestation, that an important larval concentration was missed. A system for the detection of insecticide resistance is also provided through a larval surveillance program.

Sampling Larval Mosquitoes

Because mosquito larvae are found in a wide variety of habitats, a number of different sampling techniques to determine their presence and density have been developed. Many, if not all, of the published methods are described in Mike Service's book, Mosquito Ecology Field Sampling Methods (Elsevier

Applied Science, 1993). Some methods are complex mechanical devices, but the most commonly used larval collection method is the "standard dipper," that plastic or metal, white or aluminum, solid or screen-bottomed pint to quart-sized scoop-on-a-handle, that, along with the "sweep net," defines the Ultimate Inspector. Let's take a closer look at dipping.

Dipping for mosquito larvae may, at first, seem like a very simple thing to do. After all, who hasn't dipped water from a bucket or stream to quench a thirst or cool the top of one's head? Well, think again. Dipping for mosquito larvae is not dipping to take a drink. The technique starts long before the dipper is put into the water. It begins hours or days before the actual dipping and at least 10 feet away from the water's edge.

The species of mosquitoes one is looking for and the type of habitat being sampled will, in part, determine the sampling method used. Thus, it is important that field personnel know the preferred breeding habitats and seasonal occurrence of species known or suspected to be present within an area.

When searching for mosquito larvae, proceed slowly and carefully. Approach the area with caution, not to avoid snakes, although that's a good idea too, but to avoid disturbing larvae at the water's surface. Vibrations from heavy footsteps, casting a shadow or moving vegetation that contacts the water may be enough to cause larvae to dive to the bottom. Try to approach the water while facing the sun and with quiet, slow, soft steps, gently move vegetation only as necessary.

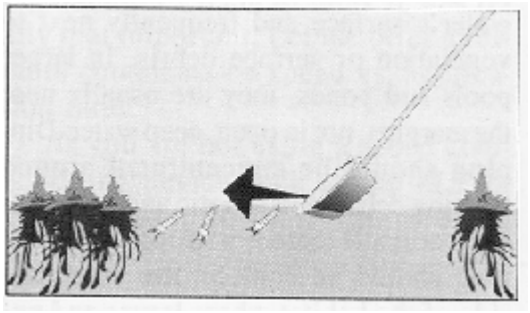
Mosquito larvae of most genera, particularly the common *Culex*, *Aedes* and *Anopheles*, are usually found at the water's surface and frequently next to vegetation or surface debris. In larger pools and ponds, they are usually near the margins, not in open, deep water. Dipping should be concentrated around floating debris and aquatic and emergent vegetation. If there is a strong wind, dipping should be done on the windward side of the habitat where larvae and pupae will be most heavily concentrated. Look for larvae and pupae before beginning to dip, if possible. If it is raining on the water's surface, get back in the truck, go have a cup of coffee and wait until the rain stops.

Each water body may contain a number of different microhabitats which could contain different mosquito species. Microhabitats are such places as under tree roots, within clumps of emergent vegetation, under floating or overhanging vegetation and in open water. Learn to recognize different microhabitats within an area and sample as many as possible in order to obtain an accurate picture of the area's species composition.

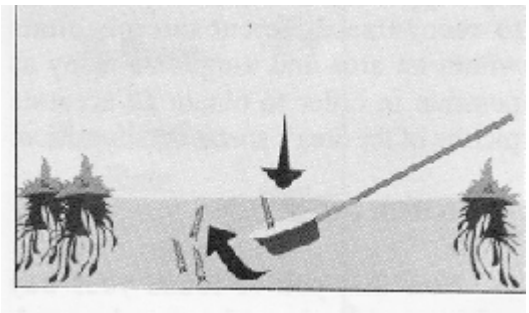
A Choice Of Seven

Now that you've found your way safely to the edge of a marsh, pond, ditch, swamp or woodland pool, what do you do with your dipper. Just plunge it in? That's fine if you need water, but not necessarily if you want to catch mosquitoes. Believe it or not, there are seven basic ways to dip for mosquito larvae. Which one or ones you use depend, as we mentioned earlier, on the genus or genera of mosquitoes you suspect may be present and on the habitat, microhabitat and weather conditions.

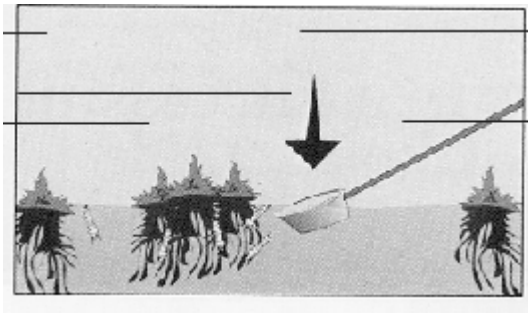
The first and usually the best method to start with is the SHALLOW SKIM. The shallow skim consists of submerging the leading edge of the dipper, tipped about 45 degrees, about an inch below the surface of the water and quickly, but gently, moving the dipper along a straight line in open water or in water with small floating debris. End the stroke just before the dipper is filled to prevent overflowing. The shallow skim is particularly effective for *Anopheles* larvae that tend to remain at the surface longer than *Aedes* and *Culex*. *Anopheles* are usually associated with floating vegetation and debris.

Fig 1 

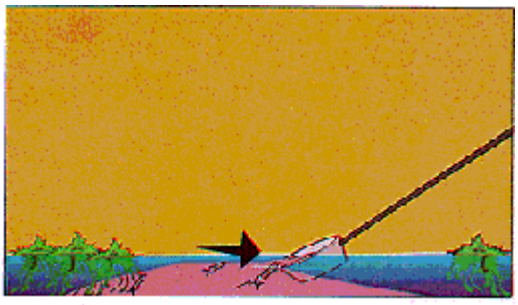
The second method to try in open water, with or without floating objects, is the COMPLETE SUBMERSION. Many mosquito larvae, particularly those of the genera *Aedes* and *Psorophora*, are very active and usually dive below the surface quickly if disturbed. In this case, a quick plunge of the dipper below the surface of the water is required, bringing the dipper back up through the diving larvae. Bring the dipper up carefully to avoid losing the larvae in the overflow current.

Fig. 2 

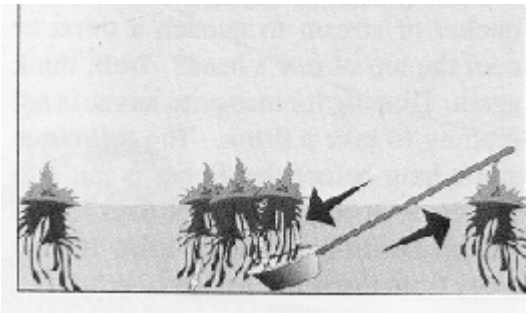
When you need to sample at the edges of emergent vegetation, try the PARTIAL SUBMERSION technique. To do this, push the dipper, tilted at about 45 degrees, straight down adjacent to the vegetation. This causes the water around the vegetation to flow into the dipper, carrying the larvae with the flow. There is no need to move the dipper horizontally. Pull the dipper up before it is full.

Fig. 3 

In very shallow water, try the FLOW-IN method. Larvae can be collected by pushing the dipper into the substrate of the pool and letting the shallow surface water, debris and larvae flow into the dipper. Do not move the dipper horizontally.

Fig. 4 

To sample for larvae that may be under floating or emergent vegetation, use the SCRAPING technique. This method is used in habitats that contain clumps of vegetation such as tussocks of sedges, floating mats of cattails or water lettuce or other plants that are too large to get in the dipper, or clumps of submerged vegetation such as hydrilla or bladderwort. Dip from the water in towards the vegetation and end by using the dipper to scrape up against the base or underside of the vegetation to dislodge larvae. This method is usually more effective if the bottom of the dipper is screened and it is often used to sample for *Coquillettidia* and *Mansonia* mosquitoes.

Fig. 5 

The SIMPLE SCOOP is the "dipping to get water" method that was discouraged earlier. It consists of simply scooping a dipperful of water. This is probably the most commonly used method, particularly by new inspectors, and it is often the method referred to in much of the literature as "the

standard dipping procedure." While it can be successfully used to collect *Culex* larvae, it is still not the method of choice.

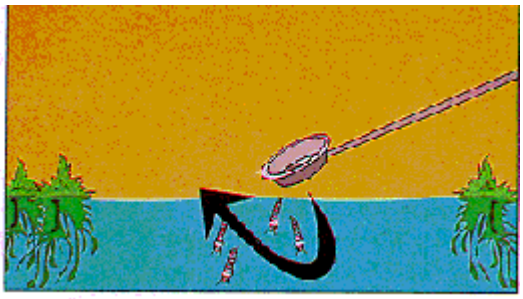


Fig. 6

The dipper can also be used as BACKGROUND. This is especially useful in woodland pools and other shallow water or when larvae are disturbed and dive to the bottom. Submerge the dipper completely to the bottom litter and slowly move it around. The darker mosquito larvae and pupae will stand out against the background of a white or aluminum dipper. Once larvae appear in the dipper, just lift it upward.

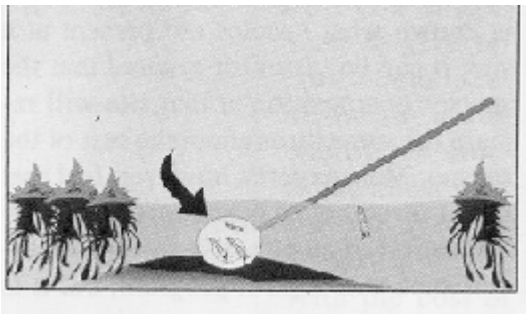


Fig. 7

One or more of these methods, properly used, can determine the mosquito species composition of most aquatic habitats, excluding those whose openings are smaller than the dipper, such as tires, rock pools, treeholes and tree root systems like those found in cedar and red maple swamps. In those cases, a smaller container, such as a vial, measuring spoon or tea strainer can be used in the same seven ways as the dipper described above. Then there is the tubular dipper, the chef's poultry baster, for those really hard to get to places like plant axils, treeholes and tree root holes.

Now that we know how to efficiently collect mosquito larvae, what do we do with the specimens and the data. That's the subject of a future article. Until then, happy dipping.

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The CDC Trap as a Special Monitoring Tool

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Proceedings of the Seventy-Sixth Annual Meeting of the New Jersey Mosquito Control Association, Inc. 1989, pp 26-33.

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Abstract

With the addition of carbon dioxide as an attractant in the form of dry ice, the CDC trap becomes a powerful surveillance tool. The CO, baited CDC trap samples a wider range of mosquito species and significantly increases the numbers of mosquitoes captured compared to a trap that utilizes light as the sole attractant. Since the specimens are captured alive, virus assays are possible. A discussion of the history, advantages, applications and guidelines for CDC trap usage are the subjects of this paper.

Introduction

The New Jersey Light Trap (Mulhern 1942), provided the mosquito control community with a mechanical device capable of sampling host seeking mosquitoes. The trap was designed with the hope of maximizing adult surveillance results and minimizing human labor and bias. At present, this trap remains a useful tool in mosquito surveillance but its design places certain restrictions on its use. Conventional usage requires electric current to power a trap that is expected to remain at a location for long periods of time. As a result, the trap proved to be inefficient as a short-term monitor of mosquito populations, particularly in areas where electric current is inaccessible.

Soon after the creation of the New Jersey Light Trap the search was on for a trap that would more adequately fulfill the needs of those in the mosquito community concerned with arbovirus surveillance. In short, a trap that was portable, capable of the collection of live specimens, and not dependent on electricity as a source of power. Over the years, a variety of trap types concerned with portability and live capture of specimens has been designed (Bellamy and Reeves 1952, Nelson and Chamberlain 1955). In 1962, the CDC miniature light trap (CDC = Centers for Disease Control) was introduced specifically for arbovirus surveillance and other short-term mosquito investigations (Sudia and Chamberlain 1962).

The CDC trap mimicked the New Jersey Light Trap in the principle of attracting mosquitoes with white light and capturing them with the down draft produced by a motor and fan. However, the CDC trap utilized lightweight components, a 6-volt battery and a live capture net. Weighing in at under two lbs, the CDC trap was quickly adopted as a standard trap type in the collection of arbovirus samples.

Equally important to a discussion of CDC traps is the research that was conducted with carbon dioxide as a mosquito attractant. Rudolfs (1922) first suggested the possibility of carbon dioxide being an

attractant; Headlee (1934) was the first to explore its potential in conjunction with a mechanical trap. Enhanced catches with carbon dioxide-baited light traps were subsequently noted (Headlee 1941, Reeves and Hammon 1942, Huffaker and Back 1943) and in 1966 Newhouse et al. created the perfect "marriage", combining carbon dioxide in the form of dry ice with the CDC Trap.

Discussion

The overall design of the CDC trap has remained intact since 1962, with only minor differences in the construction. Changes have been made to the wiring harness in relation to different types of battery utilization. The original traps were powered with 6-volt wet cell lead-acid batteries (Sudia and Chamberlain 1962) and were wired to accommodate a dipole battery hookup. Some agencies prefer the original design and CDC traps can still be purchased that will run off current supplied by a 6-volt battery (1). However, a sealed gel cell battery would appear preferable to the old wet cell type since it would eliminate any hazards associated with battery acid. Traps designed to run off current supplied by a series of disposable or rechargeable D cell batteries are also available (1, 2). The size and type of battery that is used may be determined by your agency's existing trap inventory. When new traps are being purchased, consideration should be paid to the anticipated applications of those traps and battery selection should be based on the most practical design for the task they will fulfill (Weber 1988).

Other modifications are available to facilitate special needs in surveillance. If live specimens are not a requirement, a kill jar can be substituted for the live collection net. A photoswitch option that automatically turns the trap on and off is also available. An air-actuated gate system should always be used when the trap is operated by a photoswitch. The gate stays open to allow mosquito entrance as long as the trap is running but closes to prevent specimens from escaping when the trap stops running. The gate system is a desirable option whenever a live collection net is used since it offers a measure of safety against any type of trap failure. The air-actuated gate system may be purchased as a separate unit (1) and retrofitted to any of the existing CDC trap models.

The full potential of a CDC trap cannot be obtained without the addition of dry ice. The trap was designed to use an extremely small light bulb and the light output is much weaker than the 25 watt bulb in a New Jersey light trap. Mosquitoes can be collected with light as the only attractant but the addition of dry ice greatly enhances the trap's capabilities. Newhouse et al. (1966) reported an increase of 400-500% in overall catch when the trap is supplemented with dry ice. These findings correlate well with those of Headlee (1934), the first to use carbon dioxide in conjunction with a mechanical trap. Dry ice also increases the number of species captured by 20-25% (Morris and DeFoliart 1969, Magnarelli 1975, Slaff et al. 1983) and improves the ratio of blooded and parous individuals for arbovirus surveillance (Morris and DeFoliart 1969, Feldlaufer and Crans 1979).

If the CDC trap is used with dry ice, removal of the light bulb will actually improve the collection by eliminating "trash insects", such as beetles and moths that fly readily to light (Carestia and Savage 1967). This eliminates the tedious sorting process that is a prerequisite for identification of most light trap collections. Without the light, the trap is also less noticeable, a consideration in areas where traps may be subject to theft. During the Vietnam War this aspect received especially strong attention for reasons other than theft (Miller et al. 1969, Herbert et al. 1972).

The amount of dry ice as well as the type of container used to hold it will effect the amount of carbon dioxide released over time. In most instances, a five lb. block of dry ice is sufficient to cover the normal dusk to dawn trapping period. This delivers between 400-500 ml of carbon dioxide per min., a rate that is comparable to the amount released by a large mammal (Morris and DeFoliart 1969). Insulated containers are available from the manufacturer' but they are easily constructed. A favorite of the author's is a denim drawstring bag that is large enough to hold 5 lbs of dry ice. The bag is sewn with two layers of denim separated by a layer of insulating material taken from a space blanket. A draw string is then sewn into the top of the bag to allow the opening to be cinched. The bag is hung in a position to allow the carbon dioxide to release directly next to and slightly under the aluminum hood of the CDC trap. When host-seeking mosquitoes enter the stream of gas, they are drawn into the trap by the fan.

In regions where dry ice is difficult to obtain, there are other options. One would be the purchase of a dry ice maker; another requires construction of a cylinder delivery system similar to that described by Parker et al. 1986. In both cases, the economics should be considered in relation to the projected goals and long-term benefits from the surveillance data.

Applications

Personnel involved in the surveillance of adult mosquitoes are normally faced with answering one or more basic questions, typically WHAT SPECIES ARE PRESENT and/or HOW MANY? How best to resolve those questions is dependent on a myriad of variables. These may include the amount of time available to the worker, under what field conditions the surveillance will take place, and what is the information gathered ultimately to be used for? A suitable trap is then selected to do the most efficient job. For the most part, a CDC trap is a surveillance tool that is used in special situations. Unlike the New Jersey light trap that remains stationary in a location for long periods of time, the CDC trap's portable design is intended for short term use in a variety of locations.

Circumstances usually have the surveillance specialist attempting to define an unknown mosquito population in terms of species and numbers. Additional information regarding the extent of an infestation, its disease potential and other particulars may also be desired. A common situation is a complaint of mosquito activity called in by a resident. Two or more CDC traps placed on the property would prove or

disprove the validity of the complaint. Regardless of the actual catch, the home owner is usually favorably impressed with the attention that's been paid to his or her complaint. One way of heading off potential problem areas is to survey those areas before people move into them. In Essex County, inspectors routinely survey new housing developments with CDC traps while they are still under construction.

General population checks may be required in the vicinity of proposed project sites, such as an area that is scheduled for an adulticide treatment or one that will undergo water management to determine the extent of the existing problem. In both instances, properly placed CDC traps will provide the necessary data and help direct control efforts. In the case of adulticiding, the success or failure of the control effort will be determined over a relatively short trapping period. In the latter case, surveillance at periodic intervals over the course of an entire mosquito season would help to develop and document a short term history of adult mosquito activity for the area. The success of the project after management would be determined with post management trapping to document the degree of mosquito reduction after the work was completed.

A phone survey of New Jersey's Mosquito Control Agencies and Commissions revealed that CDC traps were especially useful in areas where virus activity is suspected. This normally involves a farm where an equine death due to eastern equine encephalitis is under investigation. Collections are made by the county commission or agency and transferred to the Agricultural Experiment Station for virus assay. Sudia and Chamberlain (1967) provide a review of the proper protocol for handling collections for virus isolation attempts. They also provide a diagram of a site involving a horse death and the recommended method of CDC trap surveillance. The diagram gives a good representation of trap placement that is of value not only in the context given, but also to any situation where an unknown adult population is being surveyed. Traps in the horse scenario are placed in likely areas of mosquito-horse contact, near stables, in pastures, and in "transition" zones along the edge of the dominant vegetation ecosystems. By trapping in the edges of transition zones, the trap is more likely to attract a wider range of species and not exclude mosquitoes that host seek only in one ecosystem. With New Jersey's wide diversity in mosquito fauna, behavioral differences should be considered in any investigation trapping program.

The height at which the trap is suspended can influence the species composition of the collection. Normally, traps are hung 5-6 ft off the ground, the height at which the New Jersey light trap operates. This height is satisfactory for the majority of species encountered in routine surveillance i.e. Aedes and Culex sp., but will not adequately sample species like Culiseta melanura, which host seeks in the canopy layer (Main et al. 1966, Crans et al. in prep.). Likewise, mosquitoes that do not host-seek between dusk and dawn will either be missed or underrepresented. A dry ice baited CDC trap would be of limited value for Aedes albopictus surveillance if the trap were operated at night because Ae. albopictus is a daytime

feeder (Herbert 1972). Diurnally feeding adults can be trapped by simply adjusting the trap hours of operation to include a representative portion of daylight collection time (Newhouse et al. 1966).

The amount of carbon dioxide that is released could affect the collection by excluding species that feed on hosts with lower respiration rates than the 4-5 lbs of dry ice exudes (Morris and DeFoliart 1969). These same authors also report that dry ice attracted several species of males which showed a positive correlation with the overall mosquito density. Huffaker (1943), however, felt that carbon dioxide repulsed male mosquitoes.

Guidelines for CDC Trapping

The following guidelines are offered to minimize variability in the use of CDC traps for mosquito surveillance:

1. Whenever possible, use the CDC trap with a dry ice supplement. A 4-5 lb. block in an insulated container will mimic a large mammal's respiration and last long enough to cover the usual dusk to dawn trapping period.
2. Remove the light source when dry ice is used as an attractant; the absence of light will eliminate other photopositive insects from the collection and increase the efficiency of identification.
3. Hang the dry ice adjacent to, and slightly below, the aluminum lid of the CDC trap to draw mosquitoes as close as possible to the collection fan.
4. Whenever possible, use CDC traps with an air actuated gate system. The gate offers a measure of protection from trap failure, improperly charged batteries, late trap pick up, etc.
5. Trap at least one hour prior to dusk until one hour after dawn to insure that surveillance is conducted during the primary host-seeking periods for most species.
6. Hang the trap 5-6 ft from ground level unless specific information is needed on canopy dwellers. For most nuisance species, this height will provide a reliable indication of activity.
7. Try to set the traps along the edges of habitats to increase trapping efficiency. A trap located strictly in one ecosystem/ habitat may exclude certain species; trapping along the edge of a swamp, for example, will provide a picture of those species found not only in the swamp, but also in the nearby upland.
8. Consider two traps as the minimum number in most situations and compare your data to detect differences that may have been due to outside influences.
9. Be aware that differences do exist in the host seeking behavior of some species and that alterations from these general guidelines may be necessary to get complete surveillance data. Strictly daylight feeding species will not be accurately represented in dusk-dawn collections. A species that host seeks in tree canopies will not be accurately sampled by a trap that is suspended

5 ft from the ground. Whenever possible, become familiar with the host seeking habits of the mosquitoes being surveyed.

Conclusions

The control of adult mosquitoes begins with proper surveillance. For special surveillance of short duration, the dry ice baited CDC trap is an efficient, reliable surveillance tool for the surveillance specialist. This trap can be used to assess a homeowner's complaint, check the success of an adulticide or gather virus information. The CDC trap's portability, battery power, and efficiency add versatility to the surveillance program.

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(2) Hausherr's Machine Works, Old Freehold Road, Toms River, NJ 08753

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The New Jersey Light Trap: An Old Standard For Most Mosquito Control Programs

William C. Reinert

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Abstract

The New Jersey Light Trap is an important supplement for adult mosquito surveillance but because of differences that occur in the behavior of individual species it is important to recognize that there are factors that influence the reliability of the light trap for adult mosquito surveillance. This paper discusses the use of the New Jersey Light Trap and sets forth guidelines for its use to minimize variation in light trap data for mosquito management.

Introduction

To perform and evaluate an effective mosquito control program in any area, it is critical to know the abundance and species composition of mosquitoes in that area. The New Jersey Light Trap is one of the most commonly used tools for obtaining this information.

The New Jersey Light Trap has been used by Mosquito Control Agencies, Rutgers University and the New Jersey Department of Health since 1934, as a device for obtaining information for mosquito research and for planning the operation of mosquito control activities. The trap is a simple and practical tool for obtaining data on adult mosquito populations without the variability and costs associated with human collectors.

History of the New Jersey Light Trap

The first light trap was developed in 1927 at the New Jersey Agricultural Experiment Station and was called the "Sugar Can Trap" because of the container that was used in the design. Mulhern (1932) reported that the trap was capable of collecting as many mosquitoes between dusk and dawn as a human could in a fifteen-minute period. The original trap did not use a fan but the "Air Blast Trap" that was developed in 1930 included a light and fan mounted in a horizontal tube that rotated in response to wind. In the latter part of 1932, the trap was redesigned to be mounted vertically and was designated as the

"Model 50 Light Trap". This trap became the standard light trap used in New Jersey and later became known as the "New Jersey Light Trap".

Description of the New Jersey Light Trap

One of the major points in favor of the New Jersey Light Trap is its simplicity and ease of operation. The trap (Fig. 1), consists of a vertical metal cylinder (a) that is 9 inches in diameter with a 16 inch diameter conical roof (b) that is fitted above the top of the cylinder.

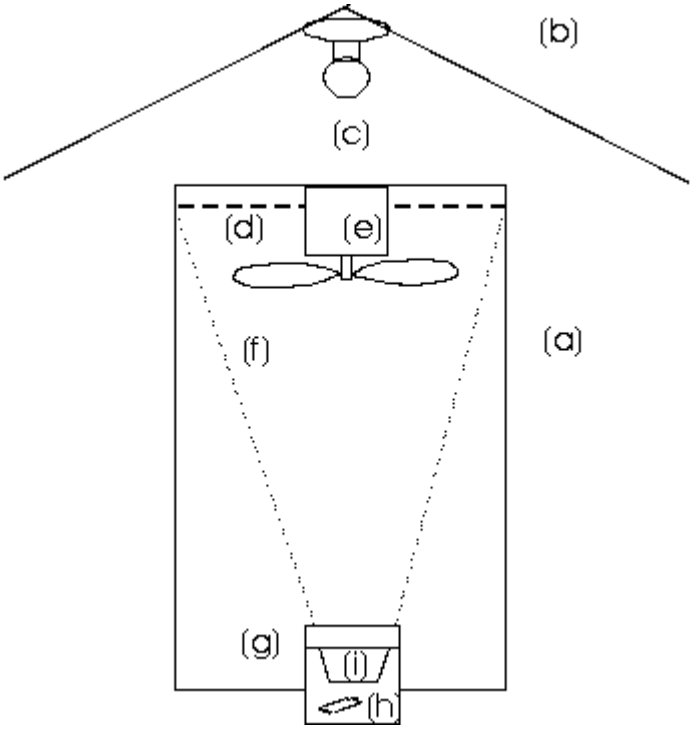

Fig. 1. The components of a New Jersey light trap.

At the apex of the underside of the roof, a socket (c) is provided for a 25 watt light bulb which attracts the mosquitoes to the trap. The entrance to the cylinder is covered with a 1/4 or 5/16 inch mesh screen, (d) to exclude larger insects such as moths and beetles. Within the cylinder, an 8 inch diameter fan (e), run by an electric motor, sucks in mosquitoes that fly to the light. Below the fan is a fine mesh funnel (f) which leads to the collection jar (g). A killing agent (h), such as a piece of vapona strip which is most commonly used today, is placed within the collection jar. A ventilated paper or plastic cup (i) (Rupp, 1984) is placed within the collection jar to separate the insects from the killing agent. The traps are normally run on household current, although they can be modified to run on battery. In most cases, the trap is turned on by an electric eye or timer just before dusk and turned off shortly after dawn.

Uses of the New Jersey Light Trap

There are two primary functions which the New Jersey Light Trap performs in mosquito surveillance programs. One is to provide a historical record of mosquito abundance and species presence in an area. Historical data show fluctuations on a year to year basis as well as fluctuations over the span of one season. This type of information can be used to document the impact of mosquito control activities and provide the justification for additional control efforts in an area. Light trap records are especially useful for program budgeting and acquiring water management and pesticide use permits.

The second function of the New Jersey Light Trap in county mosquito surveillance programs is to provide rapid information on mosquito abundance and species composition for planning and directing day-today mosquito control activities. In this function, the data acquired by the New Jersey Light Trap are used to 1) determine or to help the need, the timing, and/or the location of pesticide applications, and to monitor the results of those pesticide applications, 2) to help determine the cause of repeated mosquito complaints in a given area, and 3) as a supplement or backup to more expedient surveillance techniques such as landing or bite counts.

Factors Influencing Light Trap Reliability and Variability

The New Jersey Light Trap can be an effective tool for managing mosquito populations but mosquito species vary in their response to artificial light, climatic conditions, and other natural stimuli. As a result, a great deal of variability is possible in the attraction of mosquitoes to light traps and the accuracy of data resulting from light trap collections.

The two most important sources of variation in light trap collections include nightly variation and variation resulting from trap placement (Huffaker et al., 1932). Nightly variation results in considerable differences in the numbers of mosquitoes captured from night to night due to environmental factors (temperatures relative humidity, lunar cycle) that influence mosquito behavior. Moonlight affects both the efficiency of the light trap and the behavior of the 'mosquitoes that are being sampled. The brightness of the moon affects the contrast of the trap's light source in relation to the background light that the insect is navigating in (Barr et al., 1960) which in turn affects the attractiveness of the trap to the mosquito. Although it is generally accepted that fewer mosquitoes are caught at full moon than with a new moon, some species' flight activity increases substantially on bright versus moonless nights.

Compounding the variability resulting from moonlight, the affects of temperature and humidity on mosquito activity and light trap collections are well documented. There are varying ranges of temperature and humidity at which individual species are most active. For example, *Aedes vexans* activity intensifies as the relative humidity increases to 70%. With higher relative humidity, this mosquito shows a decline in activity (Service 1976). It is also generally accepted that *Aedes sollicitans* activity decreases

substantially when temperatures drop below 60°F. It follows, that the amount of variability of humidity, temperature, and moonlight throughout the night will affect the numbers of mosquitoes collected in a trap from night to night.

Placement variations refers to the variability of light trap collection due to the location of the trap. The variability factors of location include proximity to a mosquito source, preferred activity and resting area degree of protection from wind and the proximity to artificial background light. Studies have shown that light trap collections can vary significantly with only a 2 to 3 meter change in location (Barr et al 1963).

The actual distance that a mosquito becomes attracted to a light source is unknown but it is thought to be very short and probably varies by species (Service 1976). The affect of background light on light traps is similar to that of moonlight in that it alters the contrast of the trap light as the attraction stimulus. Each of these factors shows that location of the light trap has considerable influence on trap data when comparing species composition, trap to trap collections, and year to year comparisons of individual traps.

Factors Affecting Variability in Light Trap Collections

We in New Jersey are fortunate that New Jersey Light Traps have been in use in our State since their introduction to mosquito control. We have a good deal of experience in their use and because so many have been placed in the same locations year after year, we have a wealth of historical information.

Table 1 shows that not all mosquito species are attracted to or collected by New Jersey light traps. There is considerable variation in the relative attractiveness of different mosquito species to light. Generally, light traps do not reflect the abundance or presence of species that are negatively phototaxic or only active during the day. In addition, mosquito species that inhabit wooded areas are less attracted to light traps then those which prefer open areas.

TABLE 1.

Mosquito species which can and cannot be accurately monitored by the New Jersey Light Trap.

Species Which Can be Accurately Monitored:

- *Oc. solicits*
- *Ae. vexans*
- *Oc. cantator*
- *Oc. taeniorhynchus*
- *Oc. trivittatus*
- *Cx. pipiens*

- *Cx. salinarius*
- *An. bradleyi*
- *Cq. perturbans*
- *Ps. columbiae*

Species Which Cannot be Accurately Monitored:

- *Oc. canadensis*
- *Oc. stimulans*
- *Oc. triseriatus*
- *Oc. excrucians*
- *Ae. albopictus*
- *Cx. restuans*
- *Cx. territans*
- *An. punctipennis*
- *An. quadrimaculatus*
- *Cs. melanura*
- *Ps. ferox*
- *Ps. call*

Although many different types of light bulbs have been tried in the New Jersey light trap, the clear 25-watt bulb is most widely used. For consistency and historic accuracy, this should continue to be the bulb of choice.

Whenever possible, light traps should be placed in the same location year after year for general surveillance practices. For greater accuracy in measuring population changes, newly installed traps should be located where mosquito populations are high. When installing the trap, be mindful of exterior lighting such as spot lights, windows and exhaust vents. The trap should be placed in an open area, away from buildings, but close to trees and shrubs. Attempts should also be made to protect the traps from prevailing winds. Light traps should be installed so that the bottom of the roof is 5 1/2 feet above the ground.

Although no significant variation has been shown between trap color and species attractiveness, some variability has been suggested for *Culex tarsalis* (Barr et al., 1963) and variation may exist for other species. Mulhern (1942) suggested that light traps be painted green to blend with their surroundings and most county mosquito control agencies have adopted that recommendation. More important to the exterior trap color is the color of the underside of the roof, which is most commonly painted white. Changing this color will affect light intensity emitted by the trap (Barr et al., 1960) and increase variability in sampling.

The recommended dates for operating the New Jersey light traps are from May lst through the month of October. Early May collections need not be made as frequently as those during the remainder of the season. May collections, however, may be useful in showing the presence of early season mosquitoes which would otherwise go undetected. Climatic conditions vary considerably year to year in September and October, but trap collections at these times may prevent unwanted surprises during warm spells. Generally, light traps used in New Jersey are operated 7 nights per week, but if light trap data are only used at comparing year to year fluctuations, operating the end of the year for the traps four nights per week will provide accurate information. During the active mosquito season, light trap collections should be identified a minimum of three times per week to supply as up to date information as possible. If light traps are an agency's sole source of adult surveillance, or if they are used to determine pesticide applications, more frequent collections may be necessary.

The most critical element in using light traps to guide day to day operations is the speed and accuracy of mosquito identification. For this information to be most useful, the specimens should be identified within 24 hrs of collection. When trap collections are exceptionally high, the entire sample need not be identified. It is considered accurate to spread the collection on a grid and subsample 1/4 of the collection as long as at least 100 mosquitoes are identified. Obviously, accuracy in identification is critical to help determine the source of the mosquitoes and an appropriate control strategy.

Be aware that the males in the collection may give you useful information. Some counties routinely identify and count the male mosquitoes. In some species, males can be a reliable indicator for the later emergence of females. When using data on male mosquitoes keep in mind that the factors which create variability in female mosquito behavior quite often influence males of the same species differently.

Some agencies use timers and others use electric eyes to operate their light traps. While there has been no significant difference shown on their effect on light trap collections, traps will run at different times depending on which device is used. For consistency, it is suggested that agencies use either all timers or all electric eyes. To assure consistency traps should be calibrated at least every other year.

Management of Light Trap Data

Data collected from New Jersey Light Traps can be analyzed in a variety of ways for use by the mosquito control agency in their operations and for providing information to people outside of mosquito control. The involvement of computers in mosquito control programs dramatically increases the speed at which these data can be processed and with the use of computer graphics the data can be prepared for presentation. Some counties have been successful in adapting *Lotus 123* for light trap data processing and others are writing their own programs for this purpose. The computer is especially helpful for subjecting

light trap data to the Williams Mean analysis (Table 2), which reduces the influence of a few very high traps on the average of all traps in the series (Downing, 1976).

The following two fairly simple forms of light trap data manipulation which do not require a computer are suggested: A) because of the widely fluctuating climatic conditions in May, September, and October it is more accurate to exclude those months when comparing year to year light trap data, and B) one of the most effective ways to reduce or correct for nightly variation is to use the five point moving mean as shown in Table 2 (Downing 1976).

TABLE 2. Useful formulas for analyzing mosquito light trap data.

Formula for Williams Mean:

[EXP ({LOG (tl + 1) + LOG (t2 + 1)...}/n)]-l

Where: t = each trap collection

n = number of traps

Formula for Five Point Moving Mean:

1st point = (day 1 + day 2 + day 3 + day 4 + day 5)/5

2nd point = (day 2 + day 3 + day 4 + day 5 + day 6)/5

3rd point = (day 3 + day 4 + day 5 + day 6 + day 7)/5 etc ...

Guidelines for Using the New Jersey Light Trap

The following guidelines are presented to improve the reliability of light trap usage in county mosquito surveillance programs and encourage uniformity of light trap data throughout the state.

1. Do not rely on the New Jersey light trap as a reliable indicator for all species. Be aware that there is considerable variation in the relative attractiveness of different mosquitoes to light and evaluate your light trap data accordingly.
2. Use a clear 25-watt bulb in the trap to make your data comparable with that of other mosquito control agencies.
3. Whenever possible, place the light traps in the same location year after year.
4. Be mindful of exterior lighting when installing a light trap and try to place the trap in open areas, away from buildings at a height of 5 1/2 ft above the ground.
5. Paint the exterior of the trap green and the underside of the roof white.
6. Begin trapping May 1 of each year and continue the trapping program through the month of October. Operate the traps 2 nights per week unless the information is only to be used to compare year to year fluctuations.
7. Whenever possible, identify the collections within 24 hours.

8. Be aware that the males in the collection may give useful information. A large number of male mosquitoes is an indication that a brood of females is about to emerge in that area.
9. For consistency, use either all timers or all electric eyes in the traps that make up your surveillance program.
10. Develop a system to manage your light trap data. Use the "Williams Mean" to adjust for variations between traps and the "5 Point Moving Mean" to correct for nightly variation.

Conclusions

The New Jersey Light Trap has been and will continue to play a important role in mosquito control in New Jersey. Consistency of operation is the key to the reliability of New Jersey Light Trap use. When used consistently, New Jersey Light Traps are effective for monitoring population changes of some species, but because of species variability and the bias of trap location, the New Jersey Light Trap is generally not accurate for comparison of abundance between different mosquito species.

Acknowledgments

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Appendix C

Bird and Mammal Surveillance

Surveillance for West Nile Virus in Avian Species

April 2002

USGS National Wildlife Health Center

A sensitive indicator of West Nile virus (WNV) activity in a general geographic area is the presence of birds that are positive for WNV. A variety of approaches for dead bird surveillance have been used by states where previous WNV outbreaks have occurred. These activities have ranged from reporting and testing only dead crows in some states, to testing all bird species in other states. Approximately 88% of the dead birds that tested positive for WNV were American and Fish crows (in the *Corvidae* family). However, in a few New York counties, species other than crows were the first birds found positive for WNV and in some counties in New York and Vermont, crows were not among the birds positive for WNV. The blue jay is another member of the *Corvidae* family that appears to be quite susceptible to WNV. A great variety of *Corvidae* species are found in the western states and testing of all birds in the *Corvidae* family (includes jays, magpies, and crows) for WNV should be considered. Raptor species also appear to be very susceptible to WNV and are considered good indicator species.

During the 1999 to 2001 WNV outbreaks, birds determined to be positive for WNV were most commonly found dead. The small percentage of sick birds observed exhibited the following clinical signs: weakness; lethargy; tremors; inability to walk, fly, perch, or hold their wings normally against their body; and lack of fear of humans (easily approached). These signs of generalized illness are NOT unique to WNV infection. Birds positive for WNV were often in fair to poor physical condition with loss of fat and muscle mass particularly noticeable in the breast muscles.

Our Center requests submission of either **freshly dead** (less than 48 hours old) intact (not scavenged) bird carcasses or tissues collected from freshly dead birds. If the carcass has an odor, is soft and mushy, has skin discoloration, feathers or skin that easily rubs off, or has maggots present, it is too decomposed for testing. Based on data from the past two years, selection of *Corvidae* species or raptors will increase the probability of detecting WNV in your state. We prefer you submit kidney and spleen with tissues placed **together** in a sterile, leak-proof bag. A sample of tissue ½ inch square is adequate. If tissues other than kidney and spleen are submitted, then label each bag with the type of tissue enclosed. Make sure bag is properly sealed (Whirl-Pac bags rolled down several times and wires folded over) to avoid contamination. Also label each submission with identification information so that we can match each tissue or carcass to the corresponding submission form. Store tissues at ultra-low temperatures, package as per NWHC shipping instructions and ship them frozen on dry ice for testing. Ship tissues and carcass via overnight delivery between Monday and Thursday. This year we will extract tissues from bird carcasses for virus isolation and RT-PCR testing. Selected tissues will be put into cell culture. We will

email weekly reports to the state WNV coordinator as the samples are being processed (a weekly report will **not** be sent if there have been no new submissions and there is no new information for your state/agency). A final written report will be mailed to the state health department as testing of individual samples is completed. An overall final report with total submission information and results will be sent by email at the end of the season.

Instructions for Collection and Shipment of Animal Carcasses to the USGS National Wildlife Health Center (NWHC) for West Nile Virus Evaluation

West Nile Virus Surveillance 2002

1. Only collect freshly dead birds. Carcasses that are decomposed or scavenged have limited diagnostic value. Contact Tom Gibbs at (360) 236-3060 before shipping or if you have questions regarding the suitability of a particular bird for examination.

2. Use rubber gloves when picking up dead birds. If you do not have gloves, put your hands into plastic bags.

3. Place each bird in a plastic bag, tie shut or close, and then place inside a second bag and close. More than one individually bagged bird can be placed in the second bag. When you collect birds, take a cooler containing ice to immediately chill the carcasses.

4. Ship birds in the supplied container. **Hard containers will be returned if you label them with your return address**. Line the cooler with a large plastic bag and pack the bagged birds in the cooler with enough blue ice to keep carcasses cold. DO NOT USE WET ICE OR DRY ICE. Fill unused space with crumpled newspaper or similar absorbent material. Keep ice packs in contact with the bagged birds.

5. Complete a "Dead Bird Reporting and Submission Form for West Nile Virus" for each bird submitted for testing. (State ID Number will be the 12 digit FedEx Airbill number). PLACE A COPY OF ALL PAPERS IN A ZIPLOCK BAG INSIDE THE SHIPPING CONTAINER BUT ON THE OUTSIDE OF THE PLASTIC BAG. IF MORE THAN ONE BIRD IS SHIPPED, INCLUDE IDENTIFICATION ON EACH BIRD TO MATCH THE FORMS. Securely tape the lid closed by running strapping tape around the cooler several times.

6. Contact Kathy Converse (608) 270-2445) e-mail Kathy_Converse@usgs.gov or fax (608) 270-2415 before shipping birds by 1-day (overnight) service. Ship Monday through Thursday morning to guarantee arrival at NWHC before the weekend.

7. Freezing and thawing can make isolation of some pathogens difficult and damage tissues needed for microscopic examination. The NWHC prefers unfrozen specimens if they can be sent within 24 hours of collection or death. Guidance on when or if to freeze samples will be proved on a case-by-case basis. If you cannot call or ship within 36 hours, freeze the bird(s).

8. Label coolers:

USGS National Wildlife Health Center
6006 Schroeder Road
Madison, WI 53711

"DIAGNOSTIC SPECIMENS—WILDLIFE"

The phrase "Diagnostic Specimens—Wildlife" covers federal shipping regulations and routes the coolers with specimens to the necropsy entrance.

Guidelines for Investigating Suspect West Nile Virus Cases in Equine

July 2001

US Department of Agriculture, Animal and Plant Health Inspection Service

Introduction

In the United States, West Nile virus (WNV) has caused disease and deaths in humans, wild birds, zoo birds, and horses. Wild birds are the reservoir for the virus, which is transmitted by mosquitoes. Limiting exposure to mosquitoes and controlling mosquitoes are fundamental in preventing the disease. The purpose of this document is to guide veterinary practitioners and field personnel in investigating and reporting suspect cases of WNV infection in equine.

Equine Precautions

APHIS Veterinary Services (VS) is concerned about horses and other equine because 85 cases of illness in horses have been attributed to WNV infection since the first detection of the virus in the United States in 1999. Thirty-two (38 percent) of those horses died or were euthanatized. Many additional horses that did not develop clinical illness have been found to be infected with WNV based on detection of antibodies to the virus. No transmission of WNV has been documented from horses, either directly or through mosquitoes.

To prevent exposure of equine to WNV, it is necessary to prevent their exposure to mosquitoes. No vaccine for WNV is currently available*, although vaccine development is moving forward and a product may soon be approved for use in horses. The most important action to prevent exposure to mosquitoes is source reduction, i.e., the elimination of stagnant water sources where mosquitoes may breed. Insect-proofing stables and other measures that reduce exposure of equine to mosquitoes may be useful in areas where current WNV activity has been documented in mosquitoes, birds, humans, or equine.

**Since this article was published, vaccine for WNV has become available.*

Human Precautions

When working with an equine or other mammal showing signs of a central nervous system disorder, always take precautions to avoid exposure to rabies virus. In addition, persons visiting a premises to investigate an unknown disease condition should take measures to prevent exposure to a variety of arthropod-borne zoonotic pathogens. Application of commercially available insect repellents

containing DEET to clothing and to exposed parts of the body should be sufficient to protect oneself from mosquitoes carrying WNV.

Equine Surveillance

What should be considered a suspect case of equine WNV infection and how it should be investigated depends on whether or not it occurs in a WNV-affected area. A WNV-affected area is any county where a WNV infection in an equine has been confirmed in the current calendar year (2001), or any location within 10 miles of a confirmed equine WNV infection. A non-WNV-affected area is any county where WNV infection in equine has not been diagnosed in the current calendar year, or any location more than 10 miles from a positive equine case of WNV infection.

WNV infection in horses may include both central nervous system and peripheral nervous system signs. These signs of disease may be indistinguishable from those produced by other equine encephalitides including rabies, equine herpesvirus-1, equine protozoal myeloencephalitis, and eastern, western, or Venezuelan equine encephalomyelitis. The most common signs of WNV infection in U.S. horses have been ataxia, weakness of limbs, recumbency, muscle fasciculation, and death. Fever has been detected in less than one-quarter of all confirmed cases.

A suspect equine case in a non-WNV-affected area should be investigated as a foreign animal disease (FAD). FAD investigations should be completed in accordance with VS Memorandum 580.4. Specimens should be submitted to the National Veterinary Services Laboratories (NVSL) with an FAD investigation number in order to facilitate tracking and timely reporting of diagnostic results.

Sample Submission

Samples for submission to NVSL should be shipped by Federal Express to:

Dr. Eileen Ostlund
NVSL
1800 Dayton Road
Ames, IA 50010

Contact NVSL (phone: 515-663-7551, fax: 515-663-7348) to provide information on what is being sent. Please report the number and type of samples and relevant epidemiological information, including location of premises (county and closest city), clinical signs observed/reported, date of onset, age of animal, outcome (alive/died/euthanatized), recent travel history, and vaccination status.

Antemortem Sample Collection

Collect one serum sample in a 10 ml red-top tube or clot-separator tube. Send the serum to NVSL. Collection of a whole blood sample (in a 10 ml EDTA purple-top tube) is of less importance but may also be included.

Collection of cerebrospinal fluid (CSF) is of less importance, but if obtained it should be sent to NVSL in a red-top tube labeled with the site of collection (e.g., cervical or lumbosacral).

The NVSL does not perform testing for equine protozoal myeloencephalitis (EPM). If testing for EPM is desired, please retain sufficient quantities of serum or CSF to send for testing at another laboratory of choice.

Postmortem Sample Collection

Use appropriate protective gear when collecting and processing postmortem samples (see below, "Recommendations for Safe Practices for Conducting Necropsies of Suspected WNV Cases").

If a suspect equine is to be euthanatized, collect at least one serum sample in a 10 ml red-top tube or clot-separator tube, prior to euthanasia. Send the serum to NVSL. Collection of a whole blood sample (in a 10 ml EDTA purple-top tube) is of less importance but may also be included.

When a postmortem examination is performed on a suspect equine, the following samples should be collected in priority order listed and sent to NVSL or the State public health laboratory, as indicated:

- Fresh brain tissue (for rabies testing) -- send to State public health laboratory.
- Fresh and fixed brain tissue -- send to NVSL.
- CSF (indicate collection site, e.g., cervical or lumbosacral) -- send to NVSL.
- Fresh and fixed spinal cord segments (cervical, thoracic, and lumbar) -- send to NVSL.

Samples collected from the postmortem examination of a suspect equine and submitted to NVSL for WNV testing will be processed only after the animal has tested negative for rabies according to established protocols in a given state. The foreign animal disease diagnostician should notify NVSL of the rabies test results as soon as they are available.

Recommendations for Safe Practices for Conducting Necropsies of Suspected WNV Cases

WNV is a flavivirus transmitted in nature by mosquitoes. Infection of otherwise healthy people causes a mild febrile illness or no symptoms at all. Mortality has been reported in the elderly; immunocompromised individuals also are at a higher risk.

Although aerosol transmission of WNV is very unlikely, precautions should be taken in laboratory and field settings. The main concern should be to prevent viral contact with open wounds and mucous membranes.

Recommendations for Field Necropsy of WNV Suspect Animals:

1. Keep the use of needles and sharp instruments to a minimum.
2. Do NOT use mechanical saws to obtain spinal cord samples. For proper procedures, see "Collection of Spinal Cord Segments" below.
3. Procedures that create an aerosol should be done in a way to minimize the dispersal of the aerosol particles.
4. Wear Tyvek® disposable coveralls or, at a minimum, a solid-front, water-resistant, long-sleeve gown.
5. Wear three pairs of gloves. The innermost pair should be latex or other disposable gloves. Substantial waterproof gloves (e.g., Playtex® kitchen gloves) should be worn over the innermost pair. The gloves should be long enough for the gown sleeves to be tucked inside the gloves; duct tape may be useful for keeping sleeves inside gloves. The outermost pair of gloves should be metal or Kevlar®, e.g., a Whizard® Hand Guard (steel/Kevlar®) glove from Koch® (1-800-456-5624) or a locally purchased filleting glove. THIS OUTER PAIR OF GLOVES MUST BE WORN throughout the necropsy procedure.
6. Wear a face shield or goggles to protect mucous membranes, and wear a disposable "half mask" HEPA respirator (3M® 8293) to avoid aerosol infection.

Collection of Equine Brain Tissue

Diagrams showing the procedure for collecting equine brain tissue are reproduced from *Equine Medicine and Surgery*, 3rd ed., 1982, edited by Mansmann, McAllister, and Pratt (see the last page of these guidelines). Always use appropriate protective gear when collecting and processing samples.

Collection of Spinal Cord Segments

Collect spinal cord in 4-centimeter-long segments from cervical, thoracic, and lumbar sites.

Procedures for Obtaining Cervical Spinal Cord Segments:

1. At the vertebral column where the head has been disarticulated, remove the soft tissue from 4 or 5 cervical vertebrae.
2. Depending on the circumstances, it may be advantageous to disarticulate the cervical vertebral column from the rest of the carcass, allowing the specimen to be placed on an elevated surface for further dissection. Assistance may be needed to hold the specimen on an elevated surface for

further dissection. Assistance in holding the specimen steady, in the form of either a person or a vise, will facilitate the remaining steps.

3. Using a manual bone saw, make transverse cuts through the midportion of each of the first four vertebral bodies. This will produce four isolated segments of cervical vertebral column, each containing an intervertebral joint at its center.
4. Observe the isolated vertebral segments from the cut ends, noting the spinal cord held in place by the spinal nerves, which exit the vertebral canal through the intervertebral foramina. Grasp the dura mater with toothed thumb forceps, apply gentle traction, and snip the spinal nerves with long thin scissors (e.g., Metzenbaums). Perform this procedure at each end of the vertebral segment.
5. For sample submission: divide each cervical spinal cord segment in half; fix one half in formalin and maintain the other half as a fresh sample. Ship the fresh and fixed segments to NVSL.

Procedures for Obtaining Thoracic and Lumbar Spinal Cord Segments:

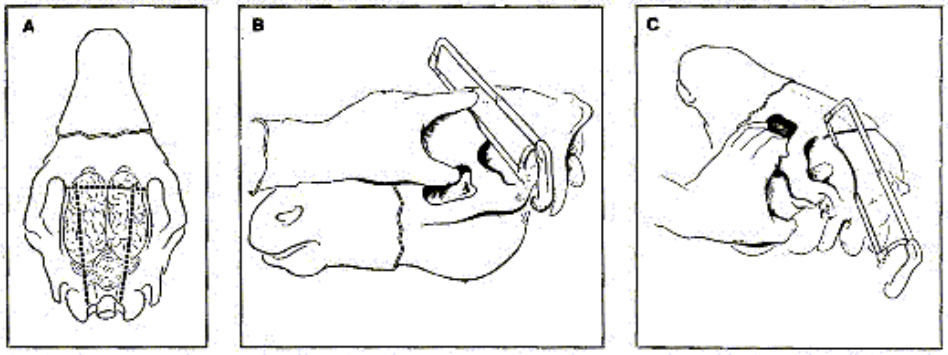
1. Excise and remove the last two ribs.
2. Remove the soft tissue around the thoracic vertebrae that have had the ribs removed. Also remove the soft tissue from around the adjacent lumbar vertebrae.
3. Basically, repeat the steps used for collecting the cervical spinal cord segments by making transverse cuts through the thoracic vertebrae and continuing down through the exposed lumbar vertebrae.
4. Remove the spinal cord segments from the vertebral segments as described for the cervical cord segments.
5. For sample submission: divide each thoracic and lumbar spinal cord segment in half; fix one half in formalin and maintain the other half as a fresh sample. Ship the fresh and fixed segments to NVSL.

Collection of CSF

A good site to collect CSF is at the atlanto-occipital junction just as one cuts through the ligaments prior to decapitation. Up to 15 ml of CSF can be collected from this site. Collect as much fluid as possible. CSF may also be collected from a sacral tap on postmortem. Identify the CSF as to site of collection and submit to NVSL.

**Mention of a commercial product, trademark, or brand name is for illustrative purposes only and does not constitute endorsement by any individual nor by any agency of the U.S. government.*

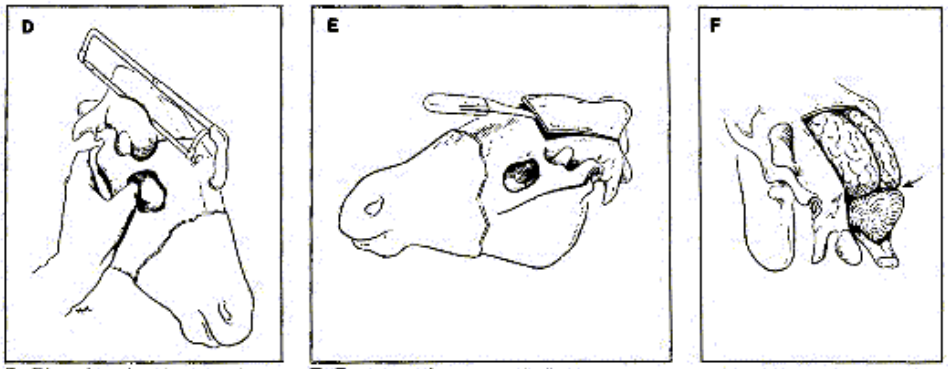
Procedure for Collecting Equine Brain Tissue



A. Dorsal view of skull showing location of brain. Remove major muscle masses from area of incisions (dotted lines).

B. Hold head with thumb in eye socket and index finger on saw blade. Cut transversely through frontal bone caudal to supraorbital process.

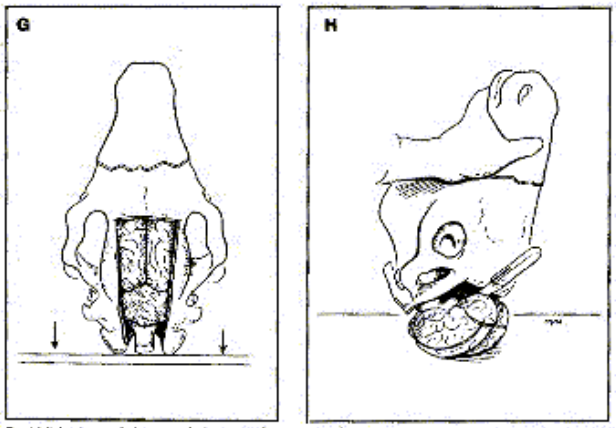
C. Place head on right side. Second cut is sagittal, just medial to left occipital condyle.



D. Place head on left side for right sagittal cut. Place nose toward you, thumb in eye socket and fingers around mandible.

E. Pry up and remove skull cap.

F. Be sure tentorium cerebelli (arrow) and other limiting dura are removed.



G. With head in upright position, tap it lightly on table to loosen brain.

H. Cut olfactory tracts and cranial nerves as brain is removed. Tilt head so that brain *rests* on table. Section, label and place in formalin.

Fig 8a. Necropsy technic for removal of the brain. [Adapted from Mod Vet Pract 60 (1979) 109]

Prevention and Control of West Nile Virus Infection in Equine and Other Livestock or Poultry

September 2002

US Department of Agriculture, Animal and Plant Health Inspection Service

West Nile virus (WNV) is a vector-borne virus that was recognized in the Western Hemisphere for the first time in 1999. Invertebrate vectors, such as mosquitoes, circulate the virus among wild birds. Occasionally the virus is introduced into other vertebrate populations, such as humans or horses, that serve as incidental hosts. Incidental hosts are infected animals that do not pass the virus on to vectors or other animals.

The only vectors found to be associated with outbreaks of WNV in the United States since 1999 are mosquitoes. At least 30 species of mosquitoes have been found positive for WNV, although several of those species are likely not involved in active transmission of the virus from bird-to-bird or from bird-to-mammal.

Horses are affected by WNV much more often than any other domestic animals. Many horses infected with WNV do not develop any illness, but of horses that become ill about one-third (33 percent) die or need to be euthanatized. Other livestock and poultry do not commonly show any illness if infected with WNV.

Given that mosquitoes are associated with WNV transmission, one key to preventing or controlling future outbreaks of WNV among horses is to control mosquito populations and to prevent horses from being exposed to any adult mosquitoes that may be present. Similar recommendations would apply for other livestock or poultry should illness due to WNV in those types of animals ever come to be recognized.

In addition to the mosquito-related prevention measures discussed below, there is now an additional action that can be taken to help prevent illness in horses caused by WNV infection: vaccination. On August 1, 2001, a conditional license was issued by the USDA-APHIS Center for Veterinary Biologics for an equine WNV vaccine. The vaccine is a killed virus product. Conditional licensing means that the product has been shown to be safe, pure, and have a reasonable expectation of efficacy in preventing illness caused by WNV. Each state veterinary authority must also approve the use of the product in their state. Because use of this vaccine is restricted to veterinarians, you need to contact your veterinarian to find out more about its use in your area. The manufacturer of the vaccine recommends giving two intramuscular doses of 1 milliliter each, 3 to 6 weeks apart, followed by an annual booster. The booster should be given just prior to the start of the mosquito season in your area.

Reduction of Mosquito Breeding Sites

Reducing the population of mosquitoes, especially species that are apparently involved with bird-to-bird transmission of WNV, such as some *Culex* species, can help to reduce or eliminate the presence of virus in a given geographical area. The most important step any property owner can take to control such mosquito populations is to remove all man-made potential sources of stagnant water in which mosquitoes might breed. Dispose of any water-holding containers, including discarded tires. Drill holes in the bottom of containers that are left outdoors. Clean clogged roof gutters annually. Turn over plastic wading pools or wheelbarrows when not in use and do not allow water to stagnate in bird baths. Clean and chlorinate swimming pools that are not in use and be aware that mosquitoes can breed in the water that collects on swimming pool covers. Aerate ornamental pools and use landscaping to eliminate standing water that collects on your property; mosquitoes can potentially breed in any stagnant puddle that lasts more than 4 days. Thoroughly clean livestock watering troughs monthly. Local mosquito control authorities may be able to help in assessing the mosquito breeding risks associated with a specific property.

Decreasing Exposure to Adult Mosquitoes

It is also important to prevent horses from being exposed to adult mosquitoes. Several actions may help in that effort.

- **Screened housing**

  Housing animals in structures with well-maintained insect screening can be useful to reduce exposure to adult mosquitoes. Use of such mosquito-resistant structures may actually lead to mosquito exposure unless precautions are first taken to eliminate mosquitoes from inside the structure. This may be accomplished through a number of means including the use of mosquito adulticides. In addition, use of fans may reduce the potential ability of mosquitoes to feed on horses.

- **Insect repellents**

  Use of insect repellents may be of some value in decreasing exposure of horses to adult mosquitoes. Due to practical limitations in the coverage area that may be achieved on any given horse with a particular product formulation, and due to limited duration of effectiveness of some formulations under certain conditions (e.g., perspiration), repellents should not be solely relied upon to prevent mosquito exposure. Repellents should be used according to their label instructions regarding appropriate species, method of application, and other precautions. Topical

application of a product containing a synthetic pyrethroid compound (e.g., permethrin) as the active ingredient may offer the best combination of safety and efficacy.

- **Outdoor exposure**

  Although some species of mosquitoes feed at dusk or dawn, others are daytime feeders or feed at any time of the day or night. As it is not yet clear which mosquitoes are responsible for the transmission of WNV to horses and other mammalian species, making recommendations as to when certain animals should avoid outdoor exposure may not be particularly useful at this time. However, a recently completed epidemiologic study of WNV suggests that keeping horses in stalls at night may be helpful in reducing their risk of infection.

How to Report Suspected Cases of West Nile Virus Disease and Submit Clinical Specimens for Laboratory Testing

Physicians and other health care providers should report suspected cases of West Nile viral disease to their local health jurisdiction or the Washington State Department of Health.

What to Report

Hospitalized adult or pediatric patients with any of the following clinical syndromes:

1. Viral encephalitis, a clinical diagnosis characterized by:
   a. Fever ≥ 38°C or 100°F, **and**
   b. CNS involvement, including altered mental status (altered level of consciousness, confusion, agitation, or lethargy) or other cortical signs (cranial nerve palsies; paresis or paralysis, or seizures), **and**
   c. Abnormal CSF profile suggestive of viral etiology: a negative bacterial stain and culture, CSF pleocytosis, predominantly lymphocytes, and/or moderately elevated protein.
2. Aseptic meningitis occurring June through September in any patient ≥ 17 years of age, characterized by:
   a. Fever ≥ 38°C or 100°F, **and**
   b. Signs of meningeal inflammation (stiff neck, headache, photophobia), **and**
   c. Abnormal CSF profile suggestive of viral etiology: a negative bacterial stain and culture, CSF pleocytosis, predominantly lymphocytes, and/or moderately elevated protein.
3. Presumed Guillain-Barre syndrome, especially with atypical features, such as fever, altered mental status and/or CSF pleocytosis.

How to Report

Contact your local health jurisdiction or call Washington State Department of Health, Communicable Disease Epidemiology's 24-hour Reporting Line at (206) 361-2914 or 1-877-539-4344. Suspected cases of West Nile viral (WNV) disease are immediately reportable in Washington State.

How to Arrange Testing

When you call to report a suspected case, we will help to determine if testing is needed, and will assist your laboratory in arranging testing. More extensive testing (viral culture, polymerase chain reaction assay, or plaque-neutralizing antibody titers) may be performed for confirmation.

Which Specimens to Obtain and When

CSF 2 tubes (if possible), without preservative, containing at least 1 cc each.

Serum 2 tubes (separated serum, not whole blood) containing at least 3 cc each.

Both CSF and serum should be obtained $\geq$ 8 days after onset of symptoms; convalescent serum may be requested for additional testing and should be obtained 2-4 weeks after onset.

CSF and sera should be refrigerated and transported cold. Frozen CSF is acceptable, but should be transported on dry ice.

Specimens should be submitted with a completed Washington State Department of Health, Public Health Laboratory *Virus and Rickettsial Examinations* form to:

Washington State Department of Health
Public Health Laboratory
1610 NE 150th Street
Shoreline, WA 98155

In cases with low probability for WNV disease (having only one or two of the clinical syndrome criteria), consider preliminary screening by testing serum for St. Louis encephalitis (SLE) IgM antibody through your clinical laboratory. SLE and WNV are closely related viruses and infection with WNV may cross-react with SLE IgM antibody. Your local health jurisdiction or Washington State Department of Health should be notified of any cases of encephalitis with SLE IgM antibody, so that follow-up testing for WNV can be performed.

Test Interpretation

IgM antibody develops by day 8, and IgG antibody usually by 3 weeks after onset. In general, convalescent specimens should be drawn about 2-3 weeks after acute specimens. A negative result on a specimen obtain < 8 days after onset of illness will be reported as "inconclusive." A convalescent

specimen, obtained at least 2 weeks after the first specimen, will be needed to make a final determination. A positive test result on an acute specimen will be reported as "suspect positive" and sent to CDC for confirmation by serum plaque-neutralizing antibody assay. Cross-reaction may occur following yellow fever or Japanese encephalitis vaccination, or with a previous history of viral encephalitis or dengue.

Appendix D

Mosquito-borne Diseases

Arboviral Encephalitides

Excerpts from the Centers for Disease Control and Prevention, Division of Vector-borne Infectious Diseases.

Information on Arboviral Encephalitides (Edited to be relevant to Washington State)

Perspectives

Arthropod-**bo**rne **viruses**, i.e., arboviruses, are viruses that are maintained in nature through biological transmission between susceptible vertebrate hosts by blood feeding arthropods (mosquitoes, psychodids, ceratopogonids, and ticks). Vertebrate infection occurs when the infected arthropod takes a blood meal. The term 'arbovirus' has no taxonomic significance. Arboviruses that cause human encephalitis are members of three virus families: the *Togaviridae* (genus Alphavirus), *Flaviviridae*, and *Bunyaviridae*.

All arboviral encephalitides are zoonotic, being maintained in complex life cycles involving a nonhuman primary vertebrate host and a primary arthropod vector. These cycles usually remain undetected until humans encroach on a natural focus, or the virus escapes this focus via a secondary vector or vertebrate host as the result of some ecologic change. Humans and domestic animals can develop clinical illness but usually are "dead-end" hosts because they do not produce significant viremia, and do not contribute to the transmission cycle. Many arboviruses that cause encephalitis have a variety of different vertebrate hosts and some are transmitted by more than one vector. Maintenance of the viruses in nature may be facilitated by vertical transmission (e.g., the virus is transmitted from the female through the eggs to the offspring).

Arboviral encephalitides have a global distribution, but there are four main virus agents of encephalitis in the United States: eastern equine encephalitis (EEE), western equine encephalitis (WEE), St. Louis encephalitis (SLE) and La Crosse (LAC) encephalitis, all of which are transmitted by mosquitoes. Most cases of arboviral encephalitis occur from June through September, when arthropods are most active. In milder (i.e., warmer) parts of the country, where arthropods are active late into the year, cases can occur into the winter months.

The majority of human infections are asymptomatic or may result in a nonspecific flu-like syndrome. Onset may be insidious or sudden with fever, headache, myalgias, malaise and occasionally prostration. Infection may, however, lead to encephalitis, with a fatal outcome or permanent neurologic sequelae. Fortunately, only a small proportion of infected persons progress to frank encephalitis.

Experimental studies have shown that invasion of the central nervous system (CNS), generally follows initial virus replication in various peripheral sites and a period of viremia. Viral transfer from the blood to the CNS through the olfactory tract has been suggested. Because the arboviral encephalitides are

viral diseases, antibiotics are not effective for treatment and no effective antiviral drugs have yet been discovered. Treatment is supportive, attempting to deal with problems such as swelling of the brain, loss of the automatic breathing activity of the brain and other treatable complications like bacterial pneumonia. There are no commercially available human vaccines for these U.S. diseases. Arboviral encephalitis can be prevented in two major ways: personal protective measures and public health measures to reduce the population of infected mosquitoes. Personal measures include reducing time outdoors particularly in early evening hours, wearing long pants and long sleeved shirts and applying mosquito repellent to exposed skin areas. Public health measures often require spraying of insecticides to kill juvenile (larvae) and adult mosquitoes.

Selection of mosquito control methods depends on what needs to be achieved; but, in most emergency situations, the preferred method to achieve maximum results over a wide area is aerial spraying. In many states aerial spraying may be available in certain locations as a means to control nuisance mosquitoes. Such resources can be redirected to areas of virus activity. When aerial spraying is not routinely used, such services are usually contracted for a given time period.

Financing of aerial spraying costs during large outbreaks is usually provided by state emergency contingency funds. Federal funding of emergency spraying is rare and almost always requires a federal disaster declaration. Such disaster declarations usually occur when the vector-borne disease has the potential to infect large numbers of people, when a large population is at risk and when the area requiring treatment is extensive. Special large planes maintained by the United States Air Force can be called upon to deliver the insecticide(s) chosen for such emergencies. Federal disaster declarations have relied heavily on risk assessment by the CDC.

Laboratory diagnosis of human arboviral encephalitis has changed greatly over the last few years. In the past, identification of antibody relied on four tests: hemagglutination-inhibition, complement fixation, plaque reduction neutralization test, and the indirect fluorescent antibody (IFA) test. Positive identification using these immunoglobulin M (IgM) - and IgG-based assays requires a four-fold increase in titer between acute and convalescent serum samples. With the advent of solid-phase antibody-binding assays, such as enzyme-linked immunosorbent assay (ELISA), the diagnostic algorithm for identification of viral activity has changed. Rapid serologic assays such as IgM-capture ELISA (MAC-ELISA) and IgG ELISA may now be employed soon after infection. Early in infection, IgM antibody is more specific, while later in infection, IgG antibody is more reactive. Inclusion of monoclonal antibodies (MAbs) with defined virus specificities in these solid phase assays has allowed for a level of standardization that was not previously possible.

Virus isolation and identification have also been useful in defining viral agents in serum, cerebrospinal fluid and mosquito vectors. While virus isolation still depends upon growth of an unknown

virus in cell culture or neonatal mice, virus identification has also been greatly facilitated by the availability of virus-specific MAbs for use in IFA assays. Similarly, MAbs with avidities sufficiently high to allow for specific binding to virus antigens in a complex protein mixture (e.g., mosquito pool suspensions) have enhanced our ability to rapidly identify virus agents *in situ*. While polymerase chain reaction (PCR) has been developed to identify a number of viral agents, such tests have not yet been validated for routine rapid identification in the clinical setting.

Mosquito-borne encephalitis offers a rare opportunity in public health to detect the risk of a disease before it occurs and to intervene to reduce that risk substantially. The surveillance required to detect risk is being increasingly refined by the potential utilization of these new technologies which allows for rapid identification of dangerous viruses in mosquito populations. These rapid diagnostic techniques used in threat recognition can shorten public health response time and reduce the geographic spread of infected vectors and thereby the cost of containing them. The Arbovirus Diseases Branch of NCID's Division of Vector-Borne Infectious Diseases has responsibility for CDC's programs in surveillance, diagnosis, research and control of arboviral encephalitides.

Western Equine Encephalitis

The alphavirus western equine encephalitis (WEE) was first isolated in California in 1930 from the brain of a horse with encephalitis, and remains an important cause of encephalitis in horses and humans in North America, mainly in western parts of the USA and Canada. In the western United States, the enzootic cycle of WEE involves passerine birds, in which the infection is inapparent, and culicine mosquitoes, principally *Cx. tarsalis*, a species that is associated with irrigated agriculture and stream drainages. The virus has also been isolated from a variety of mammal species. Other important mosquito vector species include *Ochlerotatus melanimon* in California, *Oc. dorsalis* in Utah and New Mexico and *Oc. campestris* in New Mexico. WEE virus was isolated from field collected larvae of *Oc. dorsalis*, providing evidence that vertical transmission may play an important role in the maintenance cycle of an alphavirus.

Expansion of irrigated agriculture in the North Platte River Valley during the past several decades has created habitats and conditions favorable for increases in populations of granivorous birds such as the house sparrow, *Passer domesticus*, and mosquitoes such as *Cx. tarsalis*, *Ochlerotatus dorsalis* and *Ochlerotatus melanimon.* All of these species may play a role in WEE virus transmission in irrigated areas. In addition to *Cx. tarsalis, Oc. dorsalis and Oc. melanimon*, WEE virus also has been isolated occasionally from some other mosquito species present in the area. Two confirmed and several suspect cases of WEE were reported from Wyoming in 1994. In 1995, two strains of WEE virus were isolated from *Culex tarsalis* and neutralizing antibody to WEE virus was demonstrated in sera from pheasants and

house sparrows. During 1997, 35 strains of WEE virus were isolated from mosquitoes collected in Scotts Bluff County, Nebraska.

Human WEE cases are usually first seen in June or July. Most WEE infections are asymptomatic or present as mild, nonspecific illness. Patients with clinically apparent illness usually have a sudden onset with fever, headache, nausea, vomiting, anorexia and malaise, followed by altered mental status, weakness and signs of meningeal irritation. Children, especially those under 1 year old, are affected more severely than adults and may be left with permanent sequelae, which is seen in 5 to 30% of young patients. The mortality rate is about 3%.

St. Louis Encephalitis

In the United States, the leading cause of epidemic flaviviral encephalitis is St. Louis encephalitis (SLE) virus. SLE is the most common mosquito-transmitted human pathogen in the U.S. While periodic SLE epidemics have occurred only in the Midwest and southeast, SLE virus is distributed throughout the lower 48 states. Since 1964, there have been 4,437 confirmed cases of SLE with an average of 193 cases per year (range 4 - 1,967). However, less than 1% of SLE viral infections are clinically apparent and the vast majority of infections remain undiagnosed. Illness ranges in severity from a simple febrile headache to meningoencephalitis, with an overall case-fatality ratio of 5-15 %. The disease is generally milder in children than in adults, but in those children who do have disease, there is a high rate of encephalitis. The elderly are at highest risk for severe disease and death. During the summer season, SLE virus is maintained in a mosquito-bird-mosquito cycle, with periodic amplification by peridomestic birds and *Culex* mosquitoes. In Florida, the principal vector is *Cx. nigripalpus*, in the Midwest, *Cx. pipiens pipiens* and *Cx. p. quinquefasciatus* and in the western United States, *Cx. tarsalis* and members of the *Cx. pipiens* complex.

West Nile Encephalitis

WNV is a flavivirus belonging taxonomically to the Japanese encephalitis serocomplex that includes the closely related St. Louis encephalitis (SLE) virus, Kunjin and Murray Valley encephalitis viruses, as well as others. WNV was first isolated in the West Nile Province of Uganda in 1937 (2). The first recorded epidemics occurred in Israel during 1951-1954 and in 1957. Epidemics have been reported in Europe in the Rhone delta of France in 1962 and in Romania in 1996 (3-5). The largest recorded epidemic occurred in South Africa in 1974 (6).

An outbreak of arboviral encephalitis in New York City and neighboring counties in New York state in late August and September 1999, was initially attributed to St. Louis encephalitis virus based on positive serologic findings in cerebrospinal fluid (CSF) and serum samples using a virus-specific IgM-

capture enzyme-linked immunosorbent assay (ELISA). The outbreak has been subsequently confirmed as caused by West Nile virus based on the identification of virus in human, avian, and mosquito samples. See also these MMWR articles Outbreak of West Nile-Like Viral Encephalitis -- New York, 1999. MMWR, 1999:48(38);845-9 and Update: West Nile-Like Viral Encephalitis -- New York, 1999. MMWR, 1999:48(39);890-2. A recent outbreak WN encephalitis occurred in Bucharest, Romania in 1996.

The virus that caused the New York area outbreak has been definitively identified as a strain of WNV. The genomic sequences identified to date from human brain, virus isolates from zoo birds, dead crows, and mosquito pools are identical. SLE and West Nile viruses are antigenically related, and cross reactions are observed in most serologic tests. The isolation of viruses and genomic sequences from birds, mosquitoes, and human brain tissue permitted the discovery of West Nile virus in North America and prompted more specific testing. The limitations of serologic assays emphasize the importance of isolating the virus from entomologic, clinical, or veterinary material.

Although it is not known when and how West Nile virus was introduced into North America, international travel of infected persons to New York or transport by imported infected birds may have played a role. WNV can infect a wide range of vertebrates; in humans it usually produces either asymptomatic infection or mild febrile disease, but can cause severe and fatal infection in a small percentage of patients. Within its normal geographic distribution of Africa, the Middle East, western Asia, and Europe, WNV has not been documented to cause epizootics in birds; crows and other birds with antibodies to WNV are common, suggesting that asymptomatic or mild infection usually occurs among birds in those regions. Similarly, substantial bird virulence of SLE virus has not been reported. Therefore, an epizootic producing high mortality in crows and other bird species is unusual for either WNV or SLE virus. For both viruses, migratory birds may play an important role in the natural transmission cycles and spread. Like SLE virus, WNV is transmitted principally by *Culex* species mosquitoes, but also can be transmitted by *Aedes*, *Anopheles*, *Ochlerotatus*, and other species. The predominance of urban *Culex pipiens* mosquitoes trapped during this outbreak suggests an important role for this species. Enhanced surveillance for early detection of virus activity in birds and mosquitoes will be crucial to guide control measures.

Other Arboviral Encephalitides

Many other arboviral encephalitides occur throughout the world. Most of these diseases are problems only for those individuals traveling to countries where the viruses are endemic.

West Nile Virus

Excerpts from the Centers for Disease Control and Prevention, Division of Vector-Borne Infectious Diseases.

West Nile (WN) virus has emerged in recent years in temperate regions of Europe and North America, presenting a threat to public, equine, and animal health. The most serious manifestation of WN virus infection is fatal encephalitis (inflammation of the brain) in humans and horses, as well as mortality in certain domestic and wild birds.

History

West Nile virus was first isolated from a febrile adult woman in the West Nile District of Uganda in 1937. The ecology was characterized in Egypt in the 1950s. The virus became recognized as a cause of severe human meningoencephalitis (inflammation of the spinal cord and brain) in elderly patients during an outbreak in Israel in 1957. Equine disease was first noted in Egypt and France in the early 1960s. The appearance of WN virus in North America in 1999, with encephalitis reported in humans and horses, may be an important milestone in the evolving history of this virus.

Geographic Distribution

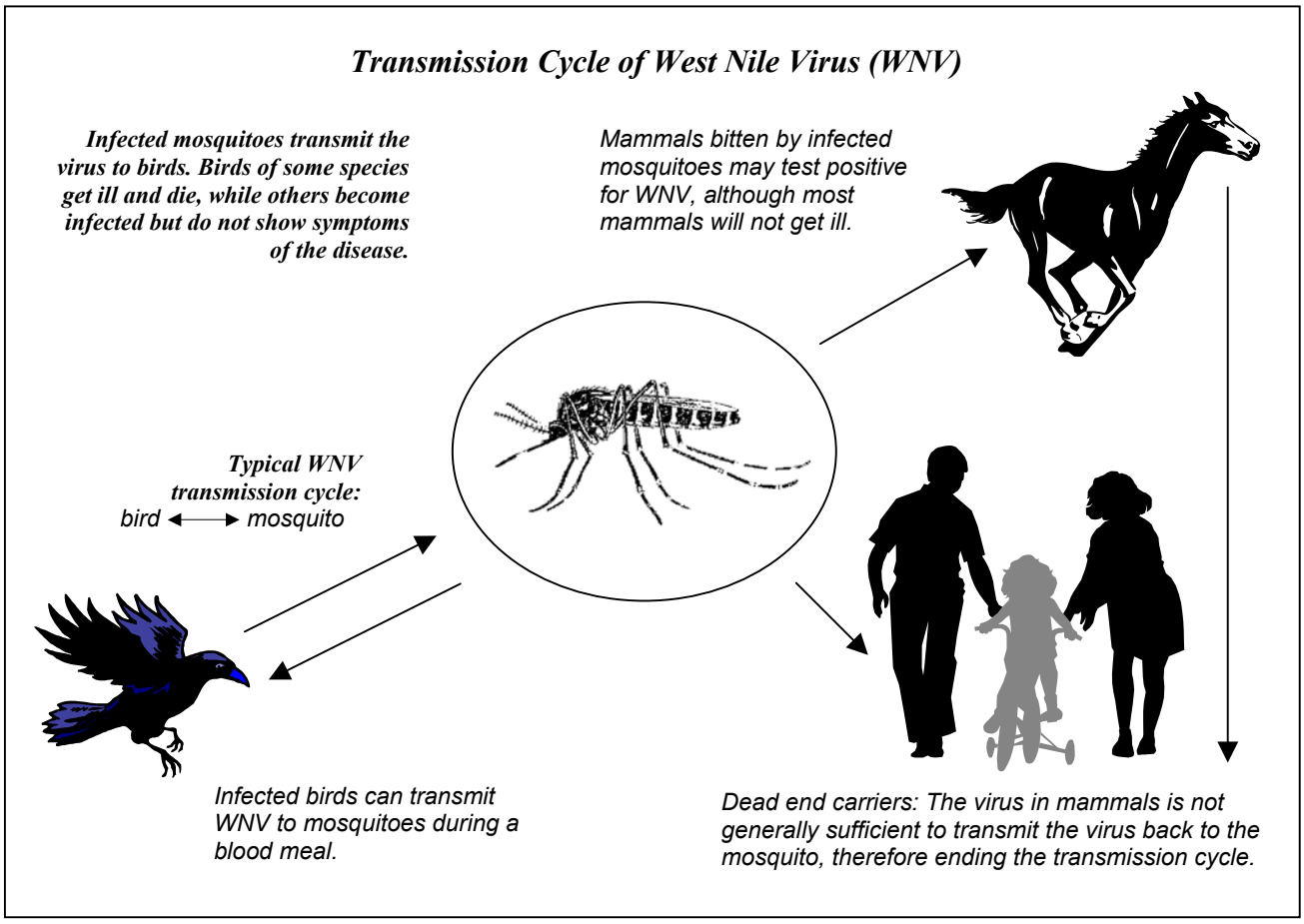
West Nile virus has been described in Africa, Europe, the Middle East, west and central Asia, Oceania (subtype Kunjin), and most recently, North America. Recent outbreaks of WN virus encephalitis in humans have occurred in Algeria in 1994, Romania in 1996-1997, the Czech Republic in 1997, the Democratic Republic of the Congo in 1998, Russia in 1999, the United States in 1999-2001, and Israel in 2000. Epizootics of disease in horses occurred in Morocco in 1996, Italy in 1998, the United States in 1999-2001, and France in 2000. In the U.S. through July 2001, WN virus has been documented in Connecticut, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Florida, Georgia, Virginia, Ohio, and the District of Columbia.

Classification

- Family: Flaviviridae
- Genus: Flavivirus Japanese Encephalitis Antigenic Complex

- Complex includes: Alfuy, Cacipacore, Japanese encephalitis, Koutango, Kunjin, Murray Valley encephalitis, St. Louis encephalitis, Rocio, Stratford, Usutu, West Nile, and Yaounde viruses.
- Flaviviruses: share a common size (40-60 nm), symmetry (enveloped, icosahedral nucleocapsid), nucleic acid (positive-sense, single stranded RNA approximately 10,000-11,000 bases), and appearance in the electron microscope.

Transmission Cycle of West Nile Virus



Appendix E

Mosquito Control

Aquatic Mosquito Control

Excerpts from Washington State Department of Ecology, Fact Sheet for Aquatic Mosquito Control General NPDES Permit.

MANAGEMENT

Mosquitoes are best managed on an area wide basis by public agencies that are either components of local health departments or are independent districts organized specifically for mosquito control. In Washington, there are approximately 12 mosquito and vector control districts. Some are small and have responsibility for mosquito abatement in a few hundred square miles, while the activities of others may encompass one entire county or more. Mosquito control is accomplished by searching out mosquito larvae in standing water and treating the water with a material that kills the larvae. Many materials currently in use are biological in origin and are highly specific for mosquitoes, with little or no effect on other organisms. On occasion, mosquito abatement agencies may also apply chemical pesticides to kill adult mosquitoes, but ordinarily only when adult populations become so large that they cause extreme annoyance to many people or when the threat of disease transmission to people is high. Control of irrigation water in agricultural areas to avoid excess runoff is an important mosquito control method, but in recent years elimination of small bodies of water that can serve as wildlife habitat has ceased to be a mosquito control option because of habitat preservation concerns.

Integrated Pest Management

Mosquito control activities are important to the public health, and responsibility for carrying out these programs rests with state and local governments. The federal government assists states in emergencies and provides training and consultation in vector and vector-borne disease problems when requested by the states. The current interests in ecology and environmental impact of mosquito control measures, and the increasing problems that have resulted from insecticide resistance emphasize the need for "integrated" control programs. IPM is an ecologically based strategy that relies heavily on natural mortality factors and seeks out control tactics that are compatible with or disrupt these factors as little as possible. IPM includes the use of pesticides, but only after systematic monitoring of mosquito populations indicates a need. Ideally, an IPM program considers all available control actions, including no action, and evaluates the interaction among various control practices, cultural practices, weather, and habitat structure. This approach thus uses a combination of resource management techniques to control mosquito populations with decisions based on surveillance. Fish and game specialists and natural resources

biologists should be involved in planning control measures whenever delicate ecosystems could be impacted by mosquito control practices.

A good integrated pest management (IPM) program -- featuring monitoring for high mosquito populations and disease, resident education and action to maximize natural controls and minimize mosquito breeding sites, and larvaciding (killing immature mosquitoes) when necessary -- can control mosquitoes more effectively while reducing pesticide exposure to humans and the environment. Insecticides are dispersed only where mosquito larvae are present and not indiscriminately, which is why larvaciding is much sounder than adulticiding.

The underlying philosophy of mosquito control is based on the fact that the greatest control impact on mosquito populations will occur when they are *concentrated, immobile* and *accessible*. This emphasis focuses on habitat management and controlling the immature stages before the mosquitoes emerge as adults. This policy reduces the need for widespread pesticide application in urban areas.

Mosquito Control Programs

In response to these potential disease-carrying pests, communities organized the earliest mosquito control programs in the eastern U.S. in the early 1900s. Eventually, other communities created similar programs throughout the country in areas where mosquito problems occurred and where citizens demanded action by local officials. Modern mosquito control programs in the U.S. are multifaceted and include surveillance, source reduction, and a variety of larval and adult mosquito control strategies.

Surveillance methods include studying habitats by air, aerial photographs, and topographic maps, and evaluating larval populations. Mosquito control officials also monitor mosquito traps, biting counts, and complaints and reports from the public. Mosquito control activities are initiated once established mosquito threshold populations are exceeded. Seasonal records are kept in concurrence with weather data to predict mosquito larval occurrence and adult flights. Some mosquito control programs conduct surveillance for diseases harbored by birds, including crows, other wild birds, sentinel chicken flocks, and for these diseases in mosquitoes.

Source reduction involves eliminating the habitat or modifying the aquatic habitat to prevent mosquitoes from breeding. This measure includes sanitation measures where artificial containers, including discarded automobile tires, which can become mosquito habitats, are collected and properly disposed. Habitat modification may also involve management of impounded water or open marshes to reduce production and survival of the floodwater mosquitoes. If habitat modification is not feasible, biological control using fish may be possible. Mosquito control officials often apply biological or chemical larvicides, with selective action and moderate residual activity, to the aquatic habitats. To have

the maximum impact on the mosquito population, larvicides are applied during those periods when immature stages are concentrated in the breeding sites and before the adult forms emerge and disperse.

Table 1. Permitted Insecticides Used for Mosquito Control

Typical Products	Active Ingredient	Label Use Rate	Use
Aquabac Bactimos Vectobac Teknar	*Bacillus thuringiensis israelensis (Bti)*	0.25 to 2 pints/acre or up to 10 lbs/acre	Larvae control
VectoLex WDG	*Bacillus sphaericus* (H-5a5b)	0.5 to 1.5 lbs/acre	Larvae control in water with high organic content
Altosid	Methoprene	2 to 20 lbs/acre	Larvae control
Agnique MMF	Monomolecular surface film	0.2 to 0.5 gal/acre	Larvae and pupae control
Golden Bear Oil Bonide Oil	Paraffinic white mineral oil	3 to 5 gal/acre	Larvae and pupae control
Malathion	Malathion	0.5 pts/acre	Emergency use only
Abate	Temephos	0.5 to 1.5 oz/acre	Emergency use only

Bacillus thuringiensis israelensis (Bti):

The product known as **Bti** (*Bacillus thuringiensis israeliensis*) can be as effective as chemical insecticides in liquid and granular form. *Bti* is an endospore-forming bacterium that is ingested by the actively feeding larvae. When the bacteria Bti encysts, it produces a protein crystal toxic to mosquito and midge larvae. Once the bacteria have been ingested, the toxin disrupts the lining of the larvae's intestine. *Bti* is highly selective for the first through third instars of mosquito and some gnat larvae. It has no effect on a vast array of other aquatic organisms except midges in the same habitat. *Bti* strains are sold under the names Bactimos®, Teknar® and Vectobac®.

Vectobac is formulated by impregnating corn kernels with bacteria known as *Bacillus thuringiensis israeliensis*. This bacterium is target specific and must be ingested by the target species to be of any effect.

Bti is the primary material used for mosquito control because of its low toxicity to non-target species. *Bti* is highly pathogenic against Culcidae (mosquitoes) and Simuliidae (blackflies) and has some virulence against certain other Diptera, especially Chironomidae (midges). Lepitdopterans are not generally considered susceptible, with some limited exceptions. Timing of treatment is important and *Bti* must be applied frequently.

Bti has been extensively studied for effects on non-target organisms and environmental consequences of use with no reported adverse effects. It is not toxic to bees. According to several studies, when applied at field application rates, *Bti* has no reported effect on fish and amphibians. Several studies

have found no effect on warm-blooded mammals. Labels indicate that direct contact with the products may cause mild to moderate eye or skin irritation.

Bti products are available in liquid, pellet and granular formulations. The type of formulation influences persistence, with the pellet/briquette forms having greater persistence. Generally *Bti* does not persist long after application, with toxicity persisting from 24 hours to over one month when the pellet/briquette formulation is used because of its slow release formula. Because of its specificity, *Bti* lacks the ability to recycle readily in insect populations. Factors that influence its persistence include UV light, agitation, sedimentation, water quality and environmental conditions such as pH and temperature.

Bacillus sphaericus:

B. sphaericus is a naturally occurring, spore-forming bacterium, which produces a protein endotoxin at the time of sporulation. The toxin is only active against the larval stage and must be ingested and digested before it becomes activated. *B. sphaericus* has the unique property of being able to control mosquito larvae in highly organic aquatic environments such as waste lagoons and storm water catch basins.

B. sphaericus is effective against *Culex spp*; it is less effective against other species. *B. sphaericus* is not acutely toxic to freshwater and saltwater invertebrates, honeybees, mayfly larvae, does not appear to be harmful to fish and other marine life, and is not toxic to birds on a sub chronic basis. In tests, *B. sphaericus* was not pathogenic, infective nor toxic in laboratory animals by the oral, dermal, pulmonary or intra-venous routes of exposure. In humans, mild skin and eye irritation can occur with direct contact.

VectoLex, the trade name for *B. sphaericus*, persists for 2-4 weeks after a single application at label rates. *B. sphaericus* may undergo limited recycling in certain organically rich environments, extending the period of larval control.

Methoprene

Methoprene mimics a natural juvenile hormone, and when present in the larval habitat it keeps immature insects from maturing into adults. Unable to metamorphose, the mosquitoes die in the pupal stage. Methoprene comes in a liquid, granular or pellet form and is applied directly to the water where mosquito larvae are found. When mosquito larvae are exposed to methoprene, their life cycle is disrupted, and they are prevented from reaching maturity or reproducing.

Studies indicate that methoprene is of low toxicity and poses little risk to people when used according to label instructions. Methoprene was not shown to have any significant toxicological effects in the standard battery of toxicity studies used to assess human health effects. The pesticide has very low

acute oral and inhalation toxicity potential and is not an eye or skin irritant. Methoprene is also of low acute dermal (skin) toxicity and is not a human skin sensitizer.

In laboratory tests, methoprene has been shown to be practically non-toxic to mallard ducks and only slightly toxic to fish. Although it has been observed to be very highly toxic to freshwater invertebrates, results from field studies involving methoprene have shown that it has no lasting adverse effects on populations of invertebrates or other non-target aquatic organisms when used according to label instructions for mosquito control. Negative impacts on aquatic invertebrates were not permanent and the populations were able to recover.

Methoprene is not persistent in the environment. It degrades rapidly in water, being susceptible to transformation by sunlight and microorganisms.

Monomolecular Surface Films

MSF is a non-petroleum surface oil that acts as a physicochemical agent by altering the mosquito's habitat. It belongs to the alcohol ethoxylate group of surfactants, which are used in detergent products. MSF disrupts the cohesive properties, which allow mosquitoes to use the water's surface as an interface for breeding. By making the surface "wetter," MSF in effect drowns mosquitoes.

MSF kills larvae and pupae by making it impossible for them to keep their breathing tubes above the water's surface. It also kills adult females by entrapping and drowning them when they contact the surface to lay their eggs. Since MSF kills mosquitoes with a physical mechanism (rather than a toxic mechanism), it is not effective in habitats with persistent unidirectional winds of greater than ten miles per hour, or in areas with very choppy water.

Some species such as the midge, and some arthropods that require attachment to the water surface have been shown to be affected. MMF is non-toxic to most non-target wildlife. The green tree frog progressed normally from tadpole to adult through several generations after being exposed to a constant film presence for six months. MMF is not a skin irritant, is only a mild eye irritant on prolonged or repeated contact, and is considered to be non-toxic by animal tests. As with all pesticides, direct contact should be avoided.

The film persistence is dependent on temperature, water flow, amount of bacteria in the water, and the duration and strength of the wind following application. Average persistence under standard use conditions is 5-14 days at recommended dosage rates.

Larvicidal oils

Oils have been used for mosquito control for more than a century. Golden Bear 1111® is a light viscosity oil that spreads quickly and evenly over the water surface, preventing larvae and pupae from obtaining oxygen through the surface film. Oils have always been used as a product of last resort for the control of mosquito pupae, since this stage does not feed but does require oxygen. The only other option would be draining the source. Closer surveillance and timing of other agents and techniques can greatly reduce the need for larvicidal oils.

Golden Bear forms a thin sheet of oil on the surface water and persists for 12 to 15 hours. It suffocates many aquatic insects by interfering with the insects' breathing tubes. Apparently, Golden Bear does not affect fish directly because the oil remains on the water's surface for only a short period of time, then evaporates. In fish-bearing waters, it may affect fish indirectly by depleting their food source. Aquatic invertebrates, amphibians, waterfowl; and furbearers may be deleteriously affected. Consequently, to determine whether any species of concern (endangered, threatened, and/or economically valuable) inhabit the area to be treated, coordination with the Department of Fish and Wildlife and Department of Natural Resources' Natural Heritage Program is required before Golden Bear oil may be used.

Chemical larvicides, organophosphates

Costs and complexity of mosquito control have increased markedly since the passage of the Environmental Protection Act in 1969. The increasing number of governmental regulations and permitting bodies, rising costs of alternative chemicals, and the spreading resistance of many vector species to existing pesticides have almost completely changed or eliminated the use of chemical control agents. The emergency use of malathion and temephos is retained under this permit with the permission of the Department of Health and Ecology. The two situations where malathion and temephos may be used are in response to pesticide resistance and where a public health emergency has been declared.

The primary application methods in aquatic mosquito larvae and pupa control are:

1. **Hand application:** Broadcast spreaders, backpack granulators and liquid sprayers are used to spread control materials either mounted on ATVs or carried by the applicator.

2. **Aerial applications:** Aerial applications normally use a conventional spray boom to improve coverage with the smaller volume of spray solution applied per acre. The spray produces a large droplet size at low pressure and low volume. The pilot

monitors the flow rate to minimize pressure and controls drift additionally through application during lower air temperatures and low wind speed.

Considerations for Adult Mosquito Control

The main objective of mosquito control is to decrease the risk of a human outbreak of mosquito-borne disease. This should be primarily accomplished by:

- Continuing to emphasize reduction in mosquito habitats;
- Larviciding where feasible and practical;
- Using personal mosquito protection measures, especially for the elderly and immunocompromised.

Adulticiding is *supplementary* to these measures and is a local decision that should be based on the considerations listed (in no particular order) below.

Triggers for Spraying

Adulticiding should be considered only when there is evidence of mosquito-borne epizootic activity at a level suggesting high risk of human infection (for example, high dead bird densities, high mosquito infection rates, multiple positive mosquito species including bridge vectors, horse or mammal cases indicating escalating epizootic transmission, or a human case with evidence of epizootic activity) and abundant adult vectors. In general, the finding of a positive bird or mosquito pool does not by itself constitute evidence of an imminent threat to human health and warrant mosquito adulticiding.

Where to Spray

Another consideration is the terrain in the proposed spraying area. If there is substantial vegetation bordering the roads, ground spraying with trucks may not provide adequate coverage. Dense vegetation associated with roadside trees, shrubs, or hedges can interfere with truck-mounted insecticide applications. In situations such as these, counties that choose to spray may wish to consider application of pesticides using backpack sprayers, or altering their route so that trucks can more efficiently apply the spray. Aerial application may be considered when all other methods of application are inadequate and/or inefficient. Aerial spraying should be limited to the immediate area where the vector population has been documented to exist through vector surveillance and to adjacent areas considered at risk for imminent disease transmission.

You can contact the Washington State Department of Ecology for guidance in situations involving spraying near water or with applications that might be hindered by vegetation.

Human Population Density

The population density in an area where there is evidence of intense epizootic activity should also be taken into consideration. It the area is rural and there are few people, the cost and potential risks of spraying may not justify its use. If the area is heavily populated, you have stronger indications for considering adult mosquito control, since the goal of spraying is to minimize the risk of a human outbreak of mosquito-borne disease.

Mosquito Population

Information from mosquito surveillance can be helpful in determining when to conduct mosquito control, and in monitoring the effectiveness of control activities. While all mosquitoes do not need to be tested specifically for the presence of viruses, those that are tested can provide valuable information regarding spraying decisions. Be aware that surveillance efforts to detect virus in birds are much easier to conduct than similar efforts to detect virus in mosquitoes. What may be more important than testing mosquitoes is knowing the NUMBERS and SPECIES of the vector population in the locality. The best way to do this is by mosquito trapping. Systematic mosquito trapping, however, requires specially trained staff and is time intensive. For localities without this capacity, there are other potential sources of information on mosquito activity. Staff can visually inspect the area where a positive bird was found, or around human population centers for habitats likely conducive to mosquito breeding. Staff can also personally observe mosquito activity.

Lag Time

It is important to look at the dates that the positive surveillance specimens (mosquitoes, birds, and/or mammals) were collected. In most cases the positive specimens will have been collected about two weeks before. In the time between the date the specimen was collected and the date when the test results are complete, circumstances may have occurred which would alter a decision to spray. For example, a county may have sprayed since the collection date, a weather event may have adversely affected mosquitoes, or mosquito habitat may have been modified resulting in a reduced need to spray.

West Nile Surveillance Results Over Time

WNV surveillance information may be monitored by county or even smaller jurisdictions, such as towns, over time, to determine what is happening with the outbreak. For example, if there has been a consistently good system for recording dead crow sightings, and the number of dead crow sightings drops for several weeks in a row after spraying, that may indicate that the previous spraying has killed off a large enough number of mosquitoes that transmission to crows is not continuing. Such analyses should not be graphed by day (because of day-to-day instability in reporting), but analysis by week should be helpful.

Local Perspectives on Spraying

Different communities have varying perspectives on the benefits of mosquito control. These should be taken into account in the decision whether or not to spray. This can be difficult, as people can have strong opinions on both side of the issue. (All chemicals used for mosquito control are United States Environmental Protection Agency approved and persons using them must also be tested and licensed by the Washington State Department of Agriculture).

For further information about toxicity of the common pesticides used for mosquito control, please check the United States Environmental Protection Agency website http://www.epa.gov/pesticides/factsheets/skeeters.htm.

Before events force a decision regarding whether to spray or not, local health jurisdictions should assess the ability to deal with a need to spray situation. Some of the questions to consider include:

- What equipment is available in the community to conduct adult mosquito control?
- Who in the community is qualified to apply mosquito control products?
- Where are vector species of mosquitoes located?
- Can local mosquito surveillance be improved to reduce the cost of mosquito control?
- Will the community need to contract for public health mosquito control?
- Who will be the lead for public health mosquito control?
- How will the community be involved and informed during the decision process?

The decision regarding spraying is basically a risk assessment: whether or not you, as a community, believe the risk of contracting a mosquito-borne disease is greater than the risk from applying pesticides for mosquito control. It is also a cost assessment where you must take into account medical costs, life years lost (for fatalities), costs of spraying campaigns, etc. As with any decision about access

to health prevention and care, many factors must be considered. Hopefully, the above list of factors will assist in your local decision making process.

If you have questions and wish to discuss your situation further, please call Tom Gibbs, Zoonotic Disease Program, Washington State Department of Health, (360) 236-3060.

Appendix F

Release of Public Information

Public Information:

Timing and Messages on Mosquitoes and Mosquito-borne Disease

Message Timing	
Early Season Messages April - June	• Your LHJ and mosquito control district are prepared. • Mosquitoes can carry disease. • Find and eliminate breeding sites. Clean up standing water around your home and your place of business. • Mosquitoes can breed in unlikely locations – a jar lid filled with water, clogged rain gutters. Discarded tires are a particular problem. • Eliminating breeding sites will help lower your risk of being bitten, and may help reduce the need for spraying later on. • Dead crows, magpies, or jays could be a sign of West Nile virus. Be sure to report them to your LHJ. Note that not all dead birds will be picked up for testing • Mosquitoes are starting to appear. • The potential for mosquito-borne disease is increasing.
High Season Messages August – September and Virus Present Messages	• Continue early season messages. • Mosquitoes are at their height. • Continue to find and eliminate mosquito-breeding sites. Eliminating breeding sites will help lower your risk of being bitten, and may help reduce the need for spraying later on. • Recognize the signs and symptoms of encephalitis and seek medical care, if needed. Mild, flu-like symptoms are not dangerous. Symptoms to be concerned about include headache with high fever, disorientation, and muscle pain and weakness. • If spraying becomes necessary, here are the facts you need, include facts such as spraying schedules, chemical facts, and known health effects.

LHJ - Local Health Jurisdiction

Early Season Message
State and County Health Departments Watching For Any Sign of West Nile Virus

Contact:

(Name)

(Phone number)

(Name)

(Phone number)

Date

A dead bird on the ground is not a sight that captures most people's immediate attention. But to officials at the _____ Department of Health (DOH), such a situation is high on the list that sparks interest and activates disease surveillance activities.

Checking dead birds, especially crows, magpies and blue jays, is one of several monitoring systems in place in Washington to detect if West Nile virus is introduced to the state, said (_____) with the state health department's Zoonotic and Vector-borne Disease Program. Others include mosquito surveillance, monitoring sentinel flocks of chickens by a mosquito control district at strategic sites, working with veterinarians who treat horses and checking tests of people hospitalized with symptoms of encephalitis.

The West Nile virus, closely related to both St. Louis encephalitis (SLE) and dengue viruses, was first seen in the United States along the East Coast in 1999. Now the virus has been reported in states ranging from New York and New Hampshire southward to Georgia and Florida. It has moved further west into (list states).

Wild birds are the principal hosts for mosquito-borne encephalitis viruses. Mosquitoes feed on infected birds, then transmit the serious, sometimes deadly organisms to humans and animals. These diseases include SLE and West Nile infections along with western equine encephalomyelitis. The illness is not spread from person-to-person or from bird-to-human.

Testing crows, magpies, and jays that have recently died is critical to the West Nile virus surveillance, (_____) said. Unlike other encephalitis viruses that do not harm the birds that carry them, West Nile virus is fatal to some species, especially crows, magpies and blue jays.

"We are asking people to call their local health department or mosquito control district when they see freshly dead birds, where it's not obviously trauma, so the birds can be tested to determine if they are infected with the West Nile virus," (_____) said.

Areas involved in the monitoring system include (number of local health jurisdictions and mosquito control districts participating). In addition, testing for. Also, military installations, universities, and community organizations send specimens for identification, (_____) said.

Mild infections of SLE may occur with a fever and headache. West Nile infections are usually unnoticed or mild with flu-like symptoms including fever, headache, sore throat, body aches and fatigue, often with skin rash and swollen lymph glands. More severe infections of both SLE and West Nile may include headache, high fever, neck stiffness, disorientation, coma, tremors, convulsions, muscle weakness and, in rare cases, death.

People may reduce their risk of encephalitis by avoiding mosquito bites and reducing mosquito-breeding sites, especially by eliminating standing water

High Season Message
West Nile Virus Expected in Washington

For Release:

Contact:

West Nile virus expected to reach Washington in 2003; state prepares

West Nile virus may reach Washington this spring, and in preparation, the state has established surveillance programs to test for its presence.

West Nile virus (WNV) was first detected in the United States in New York in 1999. It has spread west and has been detected in (___) states. The Centers for Disease Control and Prevention predicts it may reach Washington.

WNV is primarily a bird disease, and crows are especially susceptible. Dead crows, blue jays and hawks are good indicators of WNV. Mosquitoes become infected by feeding on an infected bird and pass the virus to humans, horses or other hosts when they bite. Dr. Jo Hoffman, State Epidemiologist, said most people who become infected with the virus do not become ill. Some develop mild flu-like symptoms such as fever, headache, body aches, and occasionally swollen lymph glands or a rash. In rare cases WNV may cause encephalitis, or inflammation of the brain. Individuals with severe or unusual headaches should seek medical care as soon as possible.

Local health departments and others are trapping mosquitoes in the state. Since _____, __ birds have been tested for WNV and all were negative. In addition, veterinarians are watching horses for the virus and physicians are on the alert for its presence in humans.

The Washington Department of Health offered the following suggestions to reduce the risk of being bitten by mosquitoes and to prevent transmission of WNV:

- Control and stop the breeding of mosquitoes on your property.
- Get rid of old tires and other containers where water can accumulate and serve as a breeding ground for mosquitoes.

- Avoid areas where mosquitoes are present.
- Wear long-sleeved shirts and long pants when in mosquito infested areas.
- Use mosquito repellents containing DEET, making sure to follow the directions on the container.
- Screen your doors and windows.
- A conditional horse vaccine is available. See your veterinarian.

Questions about WNV, mosquitoes and dead birds can be directed to local health departments. Individuals can visit the DOH West Nile web site at www.doh.wa.gov/ehp/ts/Zoo/WNV/WNV.html. The web site provides information about mosquito control, surveillance efforts, and submission of dead birds for testing, along with lists of other information sources. Individuals can contact the department about WNV at _____.

Virus Present Message
West Nile Virus Detected

For Release:
Contact:

West Nile Virus detected in Washington

West Nile Virus has been detected in a dead crow in _____, a state health official said today. Testing at the _____ Laboratory in _____ confirmed the virus. This is the first detection of the virus in Washington.

“West Nile has been detected in many of the surrounding states so we have been expecting to find it here as well. We have a good surveillance system in place and it worked exactly as it was supposed to," said (_____), State Epidemiologist for the Department of Health.

She encouraged people to continue submitting dead birds for testing so the department can track the spread of West Nile in Washington.

West Nile is primarily a bird disease, and crows are especially susceptible. Mosquitoes become infected by feeding on an infected bird and can pass the virus to humans, horses or other hosts when they bite. (_____) said most people who become infected do not become ill. Some may develop mild flu-like symptoms such as fever, headache, body aches, and occasionally swollen lymph glands or a rash. In rare cases West Nile may cause encephalitis, or inflammation of the brain. Individuals with severe or unusual headaches should seek medical care as soon as possible.

There have been no human or horse cases of West Nile reported in Washington. To date, __ states have detected the virus and ___ confirmed human cases have been reported nationally.

"The risk of West Nile is low but we do encourage people to take appropriate precautions to protect themselves against mosquito bites," said (_____). She offered the following suggestions to reduce the risk of exposure to West Nile:

- Get rid of old tires and other containers where water can accumulate and serve as a breeding ground for mosquitoes.
- Avoid outdoor activities at dusk and dawn when mosquitoes are most active.

- Wear long-sleeved shirts and long pants when in mosquito infested areas.

- Use mosquito repellents containing DEET, making sure to follow the directions on the container.

- Screen doors and windows.

Because horses are also at risk for West Nile, (_____) encouraged horse owners to check with their veterinarians for vaccination. Veterinarians can arrange for testing of samples from horses suspected of infection with West Nile.

A local _____submitted the bird. Many local and state agencies as well as private volunteer groups are participating in the surveillance effort with the Health Department.

Local officials and health care providers in _____ County have been notified of the virus detection.

For more information on West Nile, visit the Washington Department of Health website at www.doh.wa.gov/ehp/ts/Zoo/WNV/WNV.html the Centers for Disease Control and Prevention www.cdc.gov/ncidod/dvbid/westnile/ or contact the department at _____.

Virus Present Message
West Nile Virus Detected in Horses

For Release:
Contact:

West Nile Virus detected in Washington horses

The _____ announced today that West Nile Virus had been diagnosed in 2 horses. Laboratory results reported late Friday indicated the disease in a _____ County horse. On Saturday laboratory results reported West Nile Virus for a _____ County horse.

Washington is the ___ state to report West Nile Virus in horses in 2003. A total of ____ horses have now been confirmed with West Nile Virus in the US in 2003. Over ____ cases of West Nile Virus in horses were reported in the US in 2002.

"It is not surprising to see the disease appear in horses here" says (_____), State Veterinarian. "We've seen the virus move westward since it was first identified in birds in New York in 1999, and have been aware that the virus is in our neighboring states to the North, South and East".

West Nile Virus is not a contagious disease from horse to horse so there is no quarantine issued for this disease. West Nile Virus is carried from birds, which act as the reservoir, and spread to other animals by mosquitoes which become infected feeding on an infected bird and then feeding on other animals such as the horse. Horses are susceptible to West Nile Virus encephalitis and the disease can be confused with western encephalitis or sleeping sickness, which has existed in Washington in the past.

"While only a few horses that are exposed seem to become infected, of those that do, the death rate can be as high as 30% with little treatment options available. For this reason horse owners are encouraged to consult their veterinarian and get their horses vaccinated. West Nile Virus vaccine is conditionally licensed and studies show a minimum of 2 doses at 3-4 week intervals are required for protection," says (_____).

Virus Present Message
State Health Official Announces Probable Case

For Release:
Contact:

State health official announces probable case of human West Nile Virus

The Washington Department of Health today announced the state's first probable human case of West Nile virus. A blood sample from a resident of _____ in _____ County has tested positive at the State Public Health Laboratory. The individual is hospitalized in a _____ hospital in serious condition. The infection appears to be locally acquired.

"Given the number of West Nile positive birds and horses detected across Washington, it's not unexpected that a human case would be identified," said Mary Selecky, Secretary of Health. "The risk of human illness is low but it does increase as the intensity of animal infection increases. That's what we're seeing in Washington now that the virus has been detected in __ counties."

Selecky emphasized the risk to humans is still low and that most of those who become infected will not become ill. Some may develop mild flu-like symptoms such as fever, headache, body aches, and occasionally swollen lymph glands or a rash. In rare cases West Nile may cause encephalitis, or inflammation of the brain. Individuals with severe or unusual headaches should seek medical care as soon as possible.

The last reported human case of mosquito-borne viral encephalitis in Washington was in 1982. In the 1970's and early 1980's there were human cases of St Louis Encephalitis and Western Equine Encephalitis in the state. Since 1982 there have been no reported human cases of mosquito-borne encephalitis in Washington," said Selecky.

Secretary Selecky encouraged Washington residents to take precautions to protect against mosquito bites:

- Get rid of old tires and other containers where water can accumulate and serve as a breeding ground for mosquitoes.

- Avoid outdoor activities at dusk and dawn when mosquitoes are most active.

- Wear long-sleeved shirts and long pants when in mosquito infested areas.

- Use mosquito repellents containing DEET, making sure to follow the directions on the container.

- Screen doors and windows.

- Communities in affected areas should consider mosquito control.

Washington physicians are asked to be vigilant for patients who may be suffering from West Nile encephalitis. Human testing is available at the State Public Health Laboratory in Seattle.

Horse vaccination is recommended. Horse owners should see their veterinarians. Veterinarians can arrange for testing of samples from horses suspected of infection with West Nile.

More information about West Nile can be found on the Department of Health web site at http://www.doh.wa.gov/ehp/ts/Zoo/WNV/WNV.html.

Appendix G

Key Contacts and Web Resources

Key Contacts

State Agencies

Washington State Department of Agriculture – Animal Health

Dr. Kathleen Connell, Asst. State Veterinarian PO Box 42577 Olympia, WA 98504-2577 kconnell@agr.wa.gov	360.902.1835	Dr. Robert Mead, State Veterinarian PO Box 42577 Olympia, WA 98504-2577 rmead@agr.wa.gov	360.902.1878

Washington State Department of Ecology – Aquatic Mosquito Control Activities

Allen Moore PO Box 47600 Lacey, WA 98504-7600	360.407.6463	Nancy Weller ECY ERO N 4601 Monroe, Suite 202 Spokane, WA 99205-1295	509.625.5194

Washington State Department of Health – Zoonotic Disease Program

Tom Gibbs, Dead Bird Surveillance PO Box 47825 Olympia, WA 98504-7825 tom.gibbs@doh.wa.gov	360.236.3060	Jack Lilja, WNV Coordinator PO Box 47825 Olympia, WA 98504-7825 jack.lilja@doh.wa.gov	360.236.3366
Jo Marie Brauner, Mosquito Surveillance PO Box 47825 Olympia, WA 98504-7825 jomarie.brauner@doh.wa.gov	360.236.3064	John Grendon, PH Veterinarian PO Box 47825 Olympia, WA 98504-7825 john.grendon@doh.wa.gov	360.236.3362

Washington State Department of Health – Epidemiology, Communicable Disease Program

Communicable Disease Program PO Box 47811 Olympia, WA 98504-7811	206.361.2914	

Washington State Department of Health – Pesticide Illness Monitoring System

Pesticide Illness Monitoring System PO Box 47825 Olympia, WA 98504-7825	360.236.3360	For pesticide illness reports and pesticide toxicology.

Key Contacts

Mosquito Control Districts

Adams County Mosquito Control
Tom Haworth, Manager
P.O. Box 262
Othello, WA 99344
thaworth@cbnn.net
509.488.2661
fax 509.488.2143

Benton County Mosquito Control District
James Henricksen
6174 Van Giesen
West Richland, WA 99353
bcmc@bossig.com
509.967.2414
fax 509.967.2490

Camano Island Mosquito Control District 1
Grant Lawrence, President
359 E. Russell Road
Camano Island, WA 98282
360.387.5365
fax 360.387.6161

Clark County Mosquito Control District
Steve Kessler, Manager
Southwest Washington Health District
P.O. Box 1870
Vancouver, WA 98668
360.397.8430

Columbia Mosquito Control District
David Ensunsa, Manager
P.O. Box 297
Burbank, WA 99323
cmcd@bossig.com
509.547.4994
fax 509.547.4994

Inter-Local Mosquito Control District
Post Office Box 130
Latah, WA 99310
509.286.3471

Mosquito Control District of Cowlitz County
Tom Barton, Manager
603 North 20th
Kelso, WA 98626
360.573.7283

Curlew Mosquito Control District
Laurel Scott, Board Member
P.O. Box 231
Curlew, WA 99118-0231
discott@televar.com
509.779.4805

Grant County Mosquito Control District
Jim Thompson, Manager
735 Edgewater
Moses Lake, WA 98837
509.765.7731
fax 509.766.9005

Grant County Mosquito District #2
Mike Lowry
Electric City, WA 99123
509.633.2752
or Minnie Crane at
509.633.2289

Skamania Mosquito Control District
Nels Madsen
22 Fransworth Road
Skamania WA 98648
509.427.8055
fax 509.427.7501

Yakima County Mosquito Control District
Al Hubert, Manager
6 South 2nd Street, Suite 910
Yakima, WA 98901
509.452.1890
509.966.2314

Web Resources

Web Resources

American Mosquito Control Association
http://www.mosquito.org/

Centers for Disease Control and Prevention
Arboviral Encephalitides
http://www.cdc.gov/ncidod/dvbid/arbor/index.htm

Centers for Disease Control and Prevention
West Nile Virus
http://www.cdc.gov/ncidod/dvbid/westnile/index.htm

Cornell University, Center for the Environment
What Going on with the West Nile Virus?
http://www.cfe.cornell.edu/erap/WNV/

National Pesticide Information Center
West Nile Virus Resource Guide
http://npic.orst.edu/wnv/

Northwest Mosquito and Vector Control Association
http://www.nwmvca.org/index.html

US Department of Agriculture
West Nile Virus
http://www.aphis.usda.gov/oa/wnv/index.html

US Environmental Protection Agency
EPA and Mosquito Control
http://www.epa.gov/pesticides/factsheets/skeeters.htm

US Geological Survey
West Nile Surveillance Maps
http://cindi.usgs.gov/hazard/event/west_nile/west_nile.html

Washington State Department of Agriculture
http://www.wa.gov/agr/default.htm

Washington State Department of Health
West Nile Virus
http://www.doh.wa.gov/ehp/ts/Zoo/WNV/WNV.html

Appendix H

Revised Codes of Washington on Mosquito

Chapter 70.22 RCW
Mosquito Control

SECTIONS

RCW 70.22.005

Transfer of duties to the department of health.

The powers and duties of the secretary of social and health services under this chapter shall be performed by the secretary of health.

[1989 1st ex.s. c 9 § 246.]

NOTES: Effective date -- Severability -- 1989 1st ex.s. c 9: See RCW 43.70.910 and 43.70.920.

RCW 70.22.010

Declaration of purpose.

The purpose of this chapter is to establish a state-wide program for the control or elimination of mosquitoes as a health hazard.

[1961 c 283 § 1.]

NOTES: Mosquito control districts: Chapter 17.28 RCW.

RCW 70.22.020

Secretary may make inspections, investigations, and determinations and provide for control.

The secretary of health is hereby authorized and empowered to make or cause to be made such inspections, investigations, studies and determinations as he or she may from time to time deem advisable

in order to ascertain the effect of mosquitoes as a health hazard, and, to the extent to which funds are available, to provide for the control or elimination thereof in any or all parts of the state.
[1991 c 3 § 317; 1979 c 141 § 88; 1961 c 283 § 2.]

RCW 70.22.030

Secretary to coordinate plans.

The secretary of health shall coordinate plans for mosquito control work which may be projected by any county, city or town, municipal corporation, taxing district, state department or agency, federal government agency, or any person, group or organization, and arrange for cooperation between any such districts, departments, agencies, persons, groups or organizations.
[1991 c 3 § 318; 1979 c 141 § 89; 1961 c 283 § 3.]

RCW 70.22.040

Secretary may contract with, receive funds from entities and individuals -- Authorization for governmental entities to contract, grant funds, levy taxes.

The secretary of health is authorized and empowered to receive funds from any county, city or town, municipal corporation, taxing district, the federal government, or any person, group or organization to carry out the purpose of this chapter. In connection therewith the secretary is authorized and empowered to contract with any such county, city, or town, municipal corporation, taxing district, the federal government, person, group or organization with respect to the construction and maintenance of facilities and other work for the purpose of effecting mosquito control or elimination, and any such county, city or town, municipal corporation, or taxing district obligated to carry out the provisions of any such contract entered into with the secretary is authorized, empowered and directed to appropriate, and if necessary, to levy taxes for and pay over such funds as its contract with the secretary may from time to time require.
[1991 c 3 § 319; 1979 c 141 § 90; 1961 c 283 § 4.]

RCW 70.22.050

Powers and duties of secretary.

To carry out the purpose of this chapter, the secretary of health may:
(1) Abate as nuisances breeding places for mosquitoes as defined in RCW 17.28.170;
(2) Acquire by gift, devise, bequest, lease, or purchase, real and personal property necessary or convenient for carrying out the purpose of this chapter;

(3) Make contracts, employ engineers, health officers, sanitarians, physicians, laboratory personnel, attorneys, and other technical or professional assistants;

(4) Publish information or literature; and

(5) Do any and all other things necessary to carry out the purpose of this chapter: PROVIDED, that no program shall be permitted nor any action taken in pursuance thereof which may be injurious to the life or health of game or fish.

[1991 c 3 § 320; 1989 c 11 § 25; 1979 c 141 § 91; 1961 c 283 § 5.]

NOTES:

Severability -- 1989 c 11: See note following RCW 9A.56.220.

RCW 70.22.060

Governmental entities to cooperate with secretary.

Each state department, agency, and political subdivision shall cooperate with the secretary of health in carrying out the purposes of this chapter.

[1991 c 3 § 321; 1979 c 141 § 92; 1961 c 283 § 6.]

RCW 70.22.900

Severability -- 1961 c 283.

If any provision of this act, or its application to any person or circumstance is held invalid, the remainder of the act, or the application of the provision to other persons or circumstances is not affected. [1961 c 283 § 7.]

Chapter 17.28 RCW
Mosquito Control Districts

SECTIONS

NOTES: Special purpose districts, expenditures to recruit job candidates: RCW 42.24.170.

RCW 17.28.010 Definitions.

When used in this chapter, the following terms, words or phrases shall have the following meaning:

(1) "District" means any mosquito control district formed pursuant to this chapter.

(2) "Board" or "district board" means the board of trustees governing the district.

(3) "County commissioners" means the governing body of the county.

(4) "Unit" means all unincorporated territory in a proposed district in one county, regarded as an entity, or each city in a proposed district, likewise regarded as an entity.

(5) "Territory" means any city or county or portion of either or both city or county having a population of not less than one hundred persons.

(6) "Person" means any individual, firm, partnership, corporation, company, association, or joint stock association, and the legal successor thereof. [1957 c 153 § 1.]

RCW 17.28.020

Districts may be organized in counties -- Petition, presentment, signatures.

Any number of units of a territory within the state of Washington in Adams, Benton, Franklin, Grant, Kittitas, Walla Walla and Yakima counties or any other county may be organized as a mosquito control district under the provisions of this chapter.

A petition to form a district may consist of any number of separate instruments which shall be presented at a regular meeting of the county commissioners of the county in which the greater area of the proposed district is located. Petitions shall be signed by registered voters of each unit of the proposed district, equal in number to not less than ten percent of the votes cast in each unit respectively for the office of governor at the last gubernatorial election prior to the time of presenting the petition.

[1969 c 96 § 1; 1957 c 153 § 2.]

RCW 17.28.030

Petition method -- Description of boundaries -- Verification of signatures -- Resolution to include city.

Before a city can be included as a part of the proposed district its governing body shall have requested that the city be included by resolution, duly authenticated.

The petition shall set forth and describe the boundaries of the proposed district and it shall request that it be organized as a mosquito control district. Upon receipt of such a petition, the auditor of the county in which the greater area of the proposed district is located shall be charged with the responsibility of examining the same and certifying to the sufficiency of the signatures thereon. For the purpose of examining the signatures on such petitions, the auditor shall be permitted access to the voters' registration books of each city and county located in the proposed district and may appoint the respective county auditors and city clerks thereof as his deputies. No person may withdraw his name from a petition after it has been filed with the auditor. Within thirty days following the receipt of such petition, the auditor shall transmit the same to the board of commissioners of the county in which the greater area of the proposed district is located, together with his certificate as to the sufficiency thereof.

[1957 c 153 § 3.]

RCW 17.28.040

Petition method -- Publication of petition and notice of meeting.

Upon receipt of a duly certified petition, the board of commissioners shall cause the text of the petition to be published once a week for at least three consecutive weeks in one or more newspapers of general circulation within the county where the petition is presented and at each city a portion of which is

included in the proposed district. If any portion of the proposed district lies in another county, the petition and notice shall be likewise published in that county.

Only one copy of the petition need be published even though the district embraces more than one unit. No more than five of the names attached to the petition need appear in the publication of the petition and notice, but the number of signers shall be stated.

With the publication of the petition there shall be published a notice of the time of the meeting of the county commissioners when the petition will be considered, stating that all persons interested may appear and be heard.

[1957 c 153 § 4.]

RCW 17.28.050

Resolution method.

Such districts may also be organized upon the adoption by the county commissioners of a resolution of intention so to do, in lieu of the procedure hereinbefore provided for the presentation of petitions. In the event the county commissioners adopt a resolution of intention, such resolution shall describe the boundaries of the proposed district and shall set a time and place at which they will consider the organization of the district, and shall state that all persons interested may appear and be heard. Such resolution of intention shall be published in the same manner and for the same length of time as a petition.

[1957 c 153 § 5.]

RCW 17.28.060

Hearing -- Defective petition -- Establishment of boundaries.

At the time stated in the notice of the filing of the petition or the time mentioned in the resolution of intention, the county commissioners shall consider the organization of the district and hear those appearing and all protests and objections to it. The commissioners may adjourn the hearing from time to time, not exceeding two months in all.

No defect in the contents of the petition or in the title to or form of the notice or signatures, or lack of signatures thereto, shall vitiate any proceedings if the petition has a sufficient number of qualified signatures.

On the final hearing the county commissioners shall make such changes in the proposed boundaries as are advisable, and shall define and establish the boundaries.

[1957 c 153 § 6.]

RCW 17.28.070

Procedure to include other territory.

If the county commissioners deem it proper to include any territory not proposed for inclusion within the proposed boundaries, they shall first cause notice of intention to do so to be mailed to each owner of land in the territory whose name appears as owner on the last completed assessment roll of the county in which the territory lies, addressed to the owner at his address given on the assessment roll, or if no address is given, to his last known address; or if it is not known, at the county seat of the county in which his land lies. The notice shall describe the territory and shall fix a time, not less than two weeks from the date of mailing, when all persons interested may appear before the county commissioners and be heard.

The boundaries of a district lying in a city shall not be altered unless the governing board of the city, by resolution, consents to the alteration.

[1957 c 153 § 7.]

RCW 17.28.080

Determination of public necessity and compliance with chapter.

Upon the hearing of the petition the county commissioners shall determine whether the public necessity or welfare of the proposed territory and of its inhabitants requires the formation of the district, and shall also determine whether the petition complies with the provisions of this chapter, and for that purpose shall hear all competent and relevant testimony offered.

[1957 c 153 § 8.]

RCW 17.28.090

Declaration establishing and naming district -- Election to form district -- Establishment of district.

If, from the testimony given before the county commissioners, it appears to that board that the public necessity or welfare requires the formation of the district, it shall, by an order entered on its minutes, declare that to be its finding, and shall further declare and order that the territory within the boundaries so fixed and determined be organized as a district, under an appropriate name to be selected by the county commissioners, subject to approval of the voters of the district as hereinafter provided. The name shall contain the words "mosquito control district."

At the time of the declaration establishing and naming the district, the county commissioners shall by resolution call a special election to be held not less than thirty days and not more than sixty days from the date thereof, and shall cause to be published a notice of such election at least once a week for three consecutive weeks in a newspaper of general circulation in the county, setting forth the hours during

which the polls will be open, the boundaries of the proposed district as finally adopted, and the object of the election. If any portion of the proposed district lies in another county, a notice of such election shall likewise be published in that county.

The election on the formation of the mosquito control district shall be conducted by the auditor of the county in which the greater area of the proposed district is located in accordance with the general election laws of the state and the results thereof shall be canvassed by that county's canvassing board. For the purpose of conducting an election under this section, the auditor of the county in which the greater area of the proposed district is located may appoint the auditor of any county or the city clerk of any city lying wholly or partially within the proposed district as his deputies. No person shall be entitled to vote at such election unless he is a qualified voter under the laws of the state in effect at the time of such election and has resided within the mosquito control district for at least thirty days preceding the date of the election. The ballot proposition shall be in substantially the following form:

Top of Form

"Shall a mosquito control district be established for the area described in a resolution of the board of commissioners of . . . . . county adopted on the . . . . day of . . . . . , 19. . . ?

YES . . . . . ☐

NO . . . . . ☐

Bottom of Form

If a majority of the persons voting on the proposition shall vote in favor thereof, the mosquito control district shall thereupon be established and the county commissioners of the county in which the greater area of the district is situated shall immediately file for record in the office of the county auditor of each county in which any portion of the land embraced in the district is situated, and shall also forward to the county commissioners of each of the other counties, if any, in which any portion of the district is situated, and also shall file with the secretary of state, a certified copy of the order of the county commissioners. From and after the date of the filing of the certified copy with the secretary of state, the district named therein is organized as a district, with all the rights, privileges, and powers set forth in this chapter, or necessarily incident thereto.

If a majority of the persons voting on the proposition shall vote in favor thereof, all expenses of the election shall be paid by the mosquito control district when organized. If the proposition fails to receive a majority of votes in favor, the expenses of the election shall be borne by the respective counties in which the district is located in proportion to the number of votes cast in said counties.
[1957 c 153 § 9.]

RCW 17.28.100

Election on proposition to levy tax.

At the same election there shall be submitted to the voters residing within the district, for their approval or rejection, a proposition authorizing the mosquito control district, if formed, to levy at the earliest time permitted by law on all taxable property located within the mosquito control district a general tax, for one year, of up to twenty-five cents per thousand dollars of assessed value in excess of any constitutional or statutory limitation for authorized purposes of the mosquito control district. The proposition shall be expressed on the ballots in substantially the following form:

Top of Form

"ONE YEAR . . . . . CENTS PER THOUSAND
DOLLARS OF ASSESSED VALUE LEVY

Shall the mosquito control district, if formed, levy a general tax of . . . . . cents per thousand dollars of assessed value for one year upon all the taxable property within said district in excess of the constitutional and/or statutory tax limits for authorized purposes of the district?

YES . . . . . ☐
. . . . . .

NO . . . . . ☐ "
. . . . . .

Bottom of Form

Such proposition to be effective must be approved by a majority of at least three-fifths of the persons voting on the proposition to levy such tax in the manner set forth in Article VII, section 2(a) of the Constitution of this state, as amended by Amendment 59 and as thereafter amended.

[1982 c 217 § 1; 1973 1st ex.s. c 195 § 2; 1957 c 153 § 10.]

NOTES: Severability -- Effective dates and termination dates -- Construction -- 1973 1st ex.s. c 195: See notes following RCW 84.52.043.

RCW 17.28.110

Board of trustees -- Composition.

Within thirty days after the filing with the secretary of state of the certified copy of the order of formation, a governing board of trustees for the district shall be appointed. The district board shall be appointed as follows:

(1) If the district is situated in one county only and consists wholly of unincorporated territory, five members shall be appointed by the county commissioners of the county.

(2) If the district is situated entirely in one county and includes both incorporated and unincorporated territory one member shall be appointed from each commissioner district lying wholly or partly within the district by the county commissioners of the county, and one member from each city, the whole or part of which is situated in the district, by the governing body of the city; but if the district board created consists of less than five members, the county commissioners shall appoint from the district at large enough additional members to make a board of five members.

(3) If the district is situated in two or more counties and is comprised wholly of incorporated territory, one member shall be appointed from each commissioner district of each county or portion of a county situated in the district by the county commissioners; but if the district board created consists of less than five members, the county commissioners of the county in which the greater area of the district is situated shall appoint from the district at large enough additional members to make a board of five members.

(4) If the district is situated in two or more counties and consists of both incorporated and unincorporated territory, one member shall be appointed by the county commissioners of each of the counties from that portion of the district lying within each commissioner district within its jurisdiction; and one member from each city, a portion of which is situated in the district by the governing body of the city; but if the board created consists of less than five members, the county commissioners in which the greater area of the district is situated shall appoint from the district at large enough additional members to make a board of five members.

[1959 c 64 § 1; 1957 c 153 § 11.]

RCW 17.28.120

Board of trustees -- Name of board -- Qualification of members.

The district board shall be called "The board of trustees of . . . . . mosquito control district."

Each member of the board appointed by the governing body of a city shall be an elector of the city from which he is appointed and a resident of that portion of the city which is in the district.

Each member appointed from a county or portion of a county shall be an elector of the county and a resident of that portion of the county which is in the district.

Each member appointed at large shall be an elector of the district.

[1957 c 153 § 12.]

RCW 17.28.130

Board of trustees -- Terms -- Vacancies.

The members of the first board in any district shall classify themselves by lot at their first meeting so that:

(1) If the total membership is an even number, the terms of one-half the members will expire at the end of one year, and the terms of the remainder at the end of two years, from the second day of the calendar year next succeeding their appointment.

(2) If the total membership is an odd number, the terms of a bare majority of the members will expire at the end of one year, and the terms of the remainder at the end of two years, from the second day of the calendar year next succeeding their appointment.

The term of each subsequent member is two years from and after the expiration of the term of his predecessor.

In event of the resignation, death, or disability of any member, his successor shall be appointed by the governing body which appointed him.

[1957 c 153 § 13.]

RCW 17.28.140

Board of trustees -- Organization -- Officers -- Compensation -- Expenses.

The members of the first district board shall meet on the first Monday subsequent to thirty days after the filing with the secretary of state of the certificate of incorporation of the district. They shall organize by the election of one of their members as president and one as secretary.

The members of the district board shall serve without compensation; but the necessary expenses of each member for actual traveling in connection with meetings or business of the board may be allowed and paid.

The secretary shall receive such compensation as shall be fixed by the district board.

[1957 c 153 § 14.]

RCW 17.28.150

Board of trustees -- Meetings -- Rules -- Quorum.

The district board shall provide for the time and place of holding its regular meetings, and the manner of calling them, and shall establish rules for its proceedings.

Special meetings may be called by three members, notice of which shall be given to each member at least twenty-four hours before the meeting.

All of its sessions, whether regular or special, shall be open to the public.

A majority of the members shall constitute a quorum for the transaction of business.

[1957 c 153 § 15.]

RCW 17.28.160

Powers of district.

A mosquito control district organized under this chapter may:

(1) Take all necessary or proper steps for the extermination of mosquitoes.

(2) Subject to the paramount control of the county or city in which they exist, abate as nuisances all stagnant pools of water and other breeding places for mosquitoes.

(3) If necessary or proper, in the furtherance of the objects of this chapter, build, construct, repair, and maintain necessary dikes, levees, cuts, canals, or ditches upon any land, and acquire by purchase, condemnation, or by other lawful means, in the name of the district, any lands, rights of way, easements, property, or material necessary for any of those purposes.

(4) Make contracts to indemnify or compensate any owner of land or other property for any injury or damage necessarily caused by the use or taking of property for dikes, levees, cuts, canals, or ditches.

(5) Enter upon without hindrance any lands within the district for the purpose of inspection to ascertain whether breeding places of mosquitoes exist upon such lands; or to abate public nuisances in accordance with this chapter; or to ascertain if notices to abate the breeding of mosquitoes upon such lands have been complied with; or to treat with oil or other larvicidal material any breeding places of mosquitoes upon such lands.

(6) Sell or lease any land, rights of way, easements, property or material acquired by the district.

(7) Issue warrants payable at the time stated therein to evidence the obligation to repay money borrowed or any other obligation incurred by the district, warrants so issued to draw interest at a rate fixed by the board payable annually or semiannually as the board may prescribe.

(8) Make contracts with the United States, or any state, municipality, or any department of those entities for carrying out the general purpose for which the district is formed.

(9) Acquire by gift, devise, bequest, lease, or purchase, real and personal property necessary or convenient for its purposes.

(10) Make contracts, employ engineers, health officers, sanitarians, physicians, laboratory personnel, attorneys, and other technical or professional assistants; and publish information or literature and do any and all other things necessary or incident to the powers granted by, and to carry out the projects specified in this chapter.

[1981 c 156 § 1; 1957 c 153 § 16.]

RCW 17.28.170

Mosquito breeding places declared public nuisance -- Abatement.

Any breeding place for mosquitoes which exists by reason of any use made of the land on which it is found or of any artificial change in its natural condition is a public nuisance: PROVIDED, That conditions or usage of land which are beyond the control of the landowner or are not contrary to normal, accepted practices of water usage in the district, shall not be considered a public nuisance.

The nuisance may be abated in any action or proceeding, or by any remedy provided by law.

[1959 c 64 § 2; 1957 c 153 § 17.]

RCW 17.28.175

Control of mosquitos -- Declaration that owner is responsible.

A board established pursuant to RCW 17.28.110 may adopt, by resolution, a policy declaring that the control of mosquitos within the district is the responsibility of the owner of the land from which the mosquitos originate. To protect the public health or welfare, the board may, in accordance with policies and standards established by the board following a public hearing, adopt a regulation requiring owners of land within the district to perform such acts as may be necessary to control mosquitos.

[1990 c 300 § 2.]

RCW 17.28.185

Control of mosquitos -- Noncompliance by landowner with regulations.

(1) Whenever the board finds that the owner has not taken prompt and sufficient action to comply with regulations adopted pursuant to RCW 17.28.175 to control mosquitos originating from the owner's land, the board shall notify the owner that a violation of this chapter exists. The notice shall be in writing and sent by certified mail, or served by personal service. The notice shall provide a reasonable time

period for action to be taken to control mosquitos. If the board deems that a public nuisance or threat to public health or welfare caused by the mosquito infestation is sufficiently severe, it may require immediate control action to be taken within forty-eight hours following the time that notification is reasonably expected to have been received by the owner or agent by certified mail or personal service.

(2) If the owner does not take sufficient action to control mosquitos in accordance with the notice, the board may control them, or cause their being controlled, at the expense of the owner. The amount of such expense shall constitute a lien against the property and may be enforced by proceedings on such lien. The owner shall be liable for payment of the expenses, and nothing in this chapter shall be construed to prevent collection of any judgment on account thereof by any means available pursuant to law, in substitution for enforcement of the lien. Necessary costs and expenses, including reasonable attorneys' fees, incurred by the board in carrying out this section, may be recovered at the same time, as a part of the action filed under this section. The venue in proceedings for reimbursement of expenses brought pursuant to this section, including those involving governmental entities, shall be the county in which the real property that is the subject of the action is situated.

[1990 c 300 § 3.]

RCW 17.28.250

Interference with entry or work of district -- Penalty.

Any person who obstructs, hinders, or interferes with the entry upon any land within the district of any officer or employee of the district in the performance of his duty, and any person who obstructs, interferes with, molests, or damages any work performed by the district, is guilty of a misdemeanor.

[1957 c 153 § 25.]

RCW 17.28.251

Borrowing money or issuing warrants in anticipation of revenue.

A mosquito control district may, prior to the receipt of taxes raised by levy, borrow money or issue warrants of the district in anticipation of revenue, and such warrants shall be redeemed from the first money available from such taxes.

[1959 c 64 § 3.]

RCW 17.28.252

Excess levy authorized.

A mosquito control district shall have the power to levy additional taxes in excess of the constitutional and/or statutory limitations for any of the authorized purposes of such district, not in excess of fifty cents per thousand dollars of assessed value per year when authorized so to do by the electors of

such district by a three-fifths majority of those voting on the proposition in the manner set forth in Article VII, section 2(a) of the Constitution of this state, as amended by Amendment 59 and as thereafter amended at such time as may be fixed by the board of trustees for the district, which special election may be called by the board of trustees of the district, at which special election the proposition of authorizing such excess levy shall be submitted in such form as to enable the voters favoring the proposition to vote "Yes" and those opposing thereto to vote "No". Nothing herein shall be construed to prevent holding the foregoing special election at the same time as that fixed for a general election.

[1973 1st ex.s. c 195 § 3; 1959 c 64 § 4.]

NOTES: Severability -- Effective dates and termination dates -- Construction -- 1973 1st ex.s. c 195: See notes following RCW 84.52.043.

RCW 17.28.253

District boundaries for tax purposes.

For the purpose of property taxation and the levying of property taxes the boundaries of the mosquito control district shall be the established official boundary of such district existing on the first day of September of the year in which the levy is made, and no such levy shall be made for any mosquito control district whose boundaries are not duly established on the first day of September of such year.

[1959 c 64 § 5.]

RCW 17.28.254

Abatement, extermination declared necessity and benefit to land.

It is hereby declared that whenever the public necessity or welfare has required the formation of a mosquito control district, the abatement or extermination of mosquitoes within the district is of direct, economic benefit to the land located within such district and is necessary for the protection of the public health, safety and welfare of those residing therein.

[1959 c 64 § 6.]

RCW 17.28.255

Classification of property -- Assessments.

The board of trustees shall annually determine the amount of money necessary to carry on the operations of the district and shall classify the property therein in proportion to the benefits to be derived from the operations of the district and in accordance with such classification shall apportion and assess the several lots, blocks, tracts, and parcels of land or other property within the district, which assessment shall be collected with the general taxes of the county or counties.

[1959 c 64 § 7.]

RCW 17.28.256

Assessments -- Roll, hearings, notices, objections, appeal, etc.

The board of trustees in assessing the property within the district and the rights, duties and liabilities of property owners therein shall be governed, insofar as is consistent with this chapter, by the provisions for county road improvement districts as set forth in RCW 36.88.090 through 36.88.110.
[1959 c 64 § 8.]

RCW 17.28.257

Assessments -- Payment, lien, delinquencies, foreclosure, etc.

The provisions of RCW 36.88.120, 36.88.140, 36.88.150, 36.88.170 and 36.88.180 governing the liens, collection, payment of assessments, delinquent assessments, interest and penalties, lien foreclosure and foreclosed property of county road improvement districts shall govern such matters as applied to mosquito control districts.
[1959 c 64 § 9.]

RCW 17.28.258

County treasurer -- Duties.

The county treasurer shall collect all mosquito control district assessments, and the duties and responsibilities herein imposed upon him shall be among the duties and responsibilities of his office for which his bond is given as county treasurer. The collection and disposition of revenue from such assessments and the depositary thereof shall be the same as for tax revenues of such districts as provided in RCW 17.28.270.
[1959 c 64 § 10.]

RCW 17.28.260
General obligation bonds -- Excess property tax levies.

A mosquito control district shall have the power to issue general obligation bonds and to pledge the full faith and credit of the district to the payment thereof, for authorized capital purposes of the mosquito control district, and to provide for the retirement thereof by excess property tax levies whenever a proposition authorizing both the issuance of such bonds and the imposition of such excess levies has been approved by the voters of the district, at an election held pursuant to RCW 39.36.050, by three-fifths of the persons voting on said proposition at said election at which such election the total number of

persons voting on such bond proposition shall constitute not less than forty percent of the total number of votes cast within the area of said mosquito control district at the last preceding county or state general election. Mosquito control districts may become indebted for capital purposes up to an amount equal to one and one-fourth percent of the value of the taxable property in the district, as the term "value of the taxable property" is defined in RCW 39.36.015.

Such bonds shall never be issued to run for a longer period than ten years from the date of issue and shall be issued and sold in accordance with chapter 39.46 RCW.

[1984 c 186 § 5; 1983 c 167 § 18; 1973 1st ex.s. c 195 § 4; 1970 ex.s. c 56 § 5; 1969 ex.s. c 232 § 65; 1957 c 153 § 26.]

NOTES:

Purpose -- 1984 c 186: See note following RCW 39.46.110.

Liberal construction -- Severability -- 1983 c 167: See RCW 39.46.010 and note following.

Severability -- Effective dates and termination dates -- Construction -- 1973 1st ex.s. c 195: See notes following RCW 84.52.043.

Purpose -- 1970 ex.s. c 56: See note following RCW 39.52.020.

Validation -- Saving -- Severability -- 1969 ex.s. c 232: See notes following RCW 39.52.020.

RCW 17.28.270
Collection, disposition, of revenue -- Depository.

All taxes levied under this chapter shall be computed and entered on the county assessment roll and collected at the same time and in the same manner as other county taxes. When collected, the taxes shall be paid into the county treasury for the use of the district.

If the district is in more than one county the treasury of the county in which the district is organized is the depository of all funds of the district.

The treasurers of the other counties shall, at any time, not oftener than twice each year, upon the order of the district board settle with the district board and pay over to the treasurer of the county where the district is organized all money in their possession belonging to the district. The last named treasurer shall give a receipt for the money and place it to the credit of the district.

[1957 c 153 § 27.]

RCW 17.28.280
Withdrawal of funds.

The funds shall only be withdrawn from the county treasury depository upon the warrant of the district board signed by its president or acting president, and countersigned by its secretary.

[1957 c 153 § 28.]

RCW 17.28.290

Matching funds.

Any part or all of the taxes collected for use of the district may be used for matching funds made available to the district by county, state, or federal governmental agencies.

[1957 c 153 § 29.]

RCW 17.28.300

Expenses of special elections.

All expenses of any special election conducted pursuant to the provisions of this chapter shall be paid by the mosquito control district.

[1957 c 153 § 30.]

RCW 17.28.310

Annual certification of assessed valuation.

It shall be the duty of the assessor of each county lying wholly or partially within the district to certify annually to the board the aggregate assessed valuation of all taxable property in his county situated in any mosquito control district as the same appears from the last assessment roll of his county.

[1957 c 153 § 31.]

RCW 17.28.320

Annexation of territory authorized -- Consent by city.

Any territory contiguous to a district may be annexed to the district. If the territory to be annexed is in a city, consent to the annexation shall first be obtained from the governing body of the city. An authenticated copy of the resolution or order of that body consenting to the annexation shall be attached to the annexation petition.

[1957 c 153 § 32.]

RCW 17.28.330

Annexation of territory authorized -- Petition -- Hearing -- Boundaries.

The district board, upon receiving a written petition for annexation containing a description of the territory sought to be annexed, signed by registered voters in said territory equal in number to at least ten percent of the number of votes cast in the territory for the office of governor at the last gubernatorial election prior to the time the petition is presented, shall set the petition for hearing. It shall publish notice of the hearing along with a copy of the petition, stating the time and place set for the hearing, in each

county in which any part of the district or of the territory is situated, and in each city situated wholly or in part in the territory. Not more than five of the names attached to the petition need appear in the publication, but the number of signers shall be stated.

At the time set for the hearing the district board shall hear persons appearing in behalf of the petition and all protests and objections to it. The district board may adjourn the hearing from time to time, but not exceeding two months in all.

On the final hearing the district board shall make such changes as it believes advisable in the boundaries of the territory, and shall define and establish the boundaries. It shall also determine whether the petition meets the requirements of this chapter.

[1957 c 153 § 33.]

RCW 17.28.340

Annexation of territory authorized -- Order of annexation -- Election.

If upon the hearing the district board finds that the petition and the proceedings thereon meet the requirements of this chapter and that it is desirable and to the interests of the district and of the territory proposed to be annexed that the territory, with boundaries as fixed and determined by the district board, or any portion of it, should be annexed to the district, the board shall order the boundaries of the district changed to include the territory, or portion of the territory, subject to approval of the electors of the territory proposed to be annexed. The election to be conducted and the returns canvassed and declared insofar as is practicable in accordance with the requirements of this chapter for the formation of a district. The expenses of such election shall be borne by the mosquito control district regardless of the outcome of the election.

The order of annexation shall describe the boundaries of the annexed territory and that portion of the boundary of the district which coincides with any boundary of the territory. If necessary in making this order, the board may have any portion of the boundaries surveyed.

If more than one petition for the annexation of the territory has been presented, the district board may in one order include in the district any number of separate territories.

[1957 c 153 § 34.]

RCW 17.28.350

Annexation of territory authorized -- Filing of order -- Composition of board.

The order of annexation shall be entered in the minutes of the board and certified copies shall be filed with the secretary of state and with the county clerk and county auditor of each county in which the district or any part of it is situated.

From and after the date of the filing and recording of the certified copies of the order, the territory described in the order is a part of the district, with all the rights, privileges, and powers set forth in this act and those necessarily incident thereto.

After the annexation of territory to a district, the district board shall consist of the number of members and shall be appointed in the manner prescribed by this chapter for a district formed originally with boundaries embracing the annexed territory. However, the members of the district board in office at the time of the annexation shall continue to serve as members during the remainder of the terms for which they were appointed.

[1957 c 153 § 35.]

RCW 17.28.360

Consolidation of districts -- Initial proceedings.

Whenever in the judgment of the district board it is for the best interests of the district that it be consolidated with one or more other districts, it may, by a two-thirds vote of its members, adopt a resolution reciting that fact and declaring the advisability of such consolidation and the willingness of the board to consolidate. The resolution shall be sent to the board of each district with which consolidation is proposed.

The board of each district to which a proposal of consolidation is sent shall consider said proposal and give notice of its decision to the proposing board.

[1957 c 153 § 36.]

RCW 17.28.370

Consolidation of districts -- Concurrent resolution.

Should it appear that two-thirds of the members of each of the boards of districts proposed to be consolidated favor consolidation each of said boards shall then, by a vote of not less than two-thirds of its members adopt a concurrent resolution in favor of consolidation, declaring its willingness to consolidate, specifying a name for the consolidated district. Immediately upon the adoption of said concurrent resolution a copy of same signed by not less than two-thirds of the members of each board shall be forwarded to the county commissioners of the county in which all of or a major portion of the land of all, the districts consolidated are situated.

[1957 c 153 § 37.]

RCW 17.28.380

Consolidation of districts -- Election.

When the concurrent resolution for consolidation has been adopted, each board of the districts proposed for consolidation shall forthwith call a special election in its district in which shall be presented to the electors of the districts the question whether the consolidation shall be effected.

The election shall be conducted and the returns canvassed and declared insofar as is practicable in accordance with the requirements of this chapter for the formation of a district.

The board of each district shall declare the returns of the election in its district, and shall certify the results to the county commissioners of the county in which all the districts, or the major portion of the land of all the districts, are situated.

[1957 c 153 § 38.]

RCW 17.28.390

Consolidation of districts -- Order of consolidation.

Should not less than two-thirds of the votes of each of the respective districts proposed to be consolidated favor consolidation the county commissioners shall immediately:

(1) Enter an order on its minutes consolidating all of the districts proposed for consolidation into one district with name as specified in the concurrent resolution.

(2) Transmit a certified copy of the order to the county commissioners of any other county in which any portion of the consolidated district is situated.

(3) Record a copy in the office of the county auditor of each of the counties in which any portion of the consolidated district is situated.

(4) File a copy in the office of the secretary of state.

After the transmission, recording and filing of the order, the territory in the districts entering into the consolidation proposal forms a single consolidated district.

[1957 c 153 § 39.]

RCW 17.28.400

Consolidation of districts -- Composition of board.

After the consolidation, the board of the consolidated district shall consist of the number and shall be appointed in the manner prescribed by this chapter for a district originally formed.

The terms of the members of the district boards of the several districts consolidated who are in office at the time of consolidation shall terminate at the time the consolidation becomes effective.

[1957 c 153 § 40.]

RCW 17.28.410

Consolidation of districts -- Powers of consolidated district -- Indebtedness of former districts.

The consolidated district has all the rights, powers, duties, privileges and obligations of a district formed originally under the provisions of this chapter.

If at the time of consolidation there is outstanding an indebtedness of any of the former districts included in the consolidated district, that indebtedness shall be paid in the manner provided for the payment of indebtedness upon dissolution of a district.

A consolidated district shall not be liable for any indebtedness of any of the former districts included in it which was outstanding at the time of consolidation.

No property in any of the former districts shall be taxed to pay any indebtedness of any other former district existing at the date of the consolidation. [1957 c 153 § 41.]

RCW 17.28.420

Dissolution -- Election.

The district may at any time be dissolved upon the vote of two-thirds of the qualified electors in the district at a special election called by the district board upon the question. The question shall be submitted as, "Shall the district be dissolved?", or words to that effect.

Notice of the election shall be published at least once a week for at least four weeks prior to the date of the election in a newspaper of general circulation in each county of the district.
[1957 c 153 § 42.]

RCW 17.28.430

Dissolution -- Result of election to be certified -- Certificate of dissolution.

Should two-thirds or more of the votes at the election favor dissolution the district board shall certify that fact to the secretary of state. Upon receipt of such certification the secretary of state shall issue his certificate reciting that the district (naming it) has been dissolved, and shall transmit to and file a copy with the county clerk of each county in which any portion of the district is situated.

After the date of the certificate of the secretary of state, the district is dissolved.
[1957 c 153 § 43.]

RCW 17.28.440

Dissolution -- Disposition of property.

If the district at the time of dissolution was wholly within unincorporated territory in one county, its property vests in that county.

If the district at the time of dissolution was situated wholly within the boundaries of a single city, its property vests in that city.

If the district at the time of dissolution comprised only unincorporated territory in two or more counties, its property vests in those counties in proportion to the assessed value of each county's property within the boundaries of the district as shown on the last equalized county assessment roll.

If the district at the time of dissolution comprised both incorporated and unincorporated territory, its property vests in each unit in proportion as its assessed property value lies within the boundaries of the district: PROVIDED, HOWEVER, That any real property, easements, or rights of way vest in the city in which they are situated or in the county in which they are situated.

[1957 c 153 § 44.]

RCW 17.28.450

Dissolution -- Collection of taxes to discharge indebtedness.

If, at the time of election to dissolve, a district has outstanding any indebtedness, the vote to dissolve the district dissolves it for all purposes except the levy and collection of taxes for the payment of the indebtedness, and expenses of assessing, levying, and collecting such taxes.

Until the indebtedness is paid, the county commissioners of the county in which the greater portion of the district was situated shall act as the ex officio district board and shall levy taxes and perform such functions as may be necessary in order to pay the indebtedness.

[1957 c 153 § 45.]

RCW 17.28.900

Severability -- 1957 c 153.

If any part, or parts, of this chapter shall be held unconstitutional, the remaining provisions shall be given full force and effect, as completely as if the part held unconstitutional had not been included therein, if any such remaining part can then be administered in furtherance of the purposes of this chapter.

[1957 c 153 § 46.]